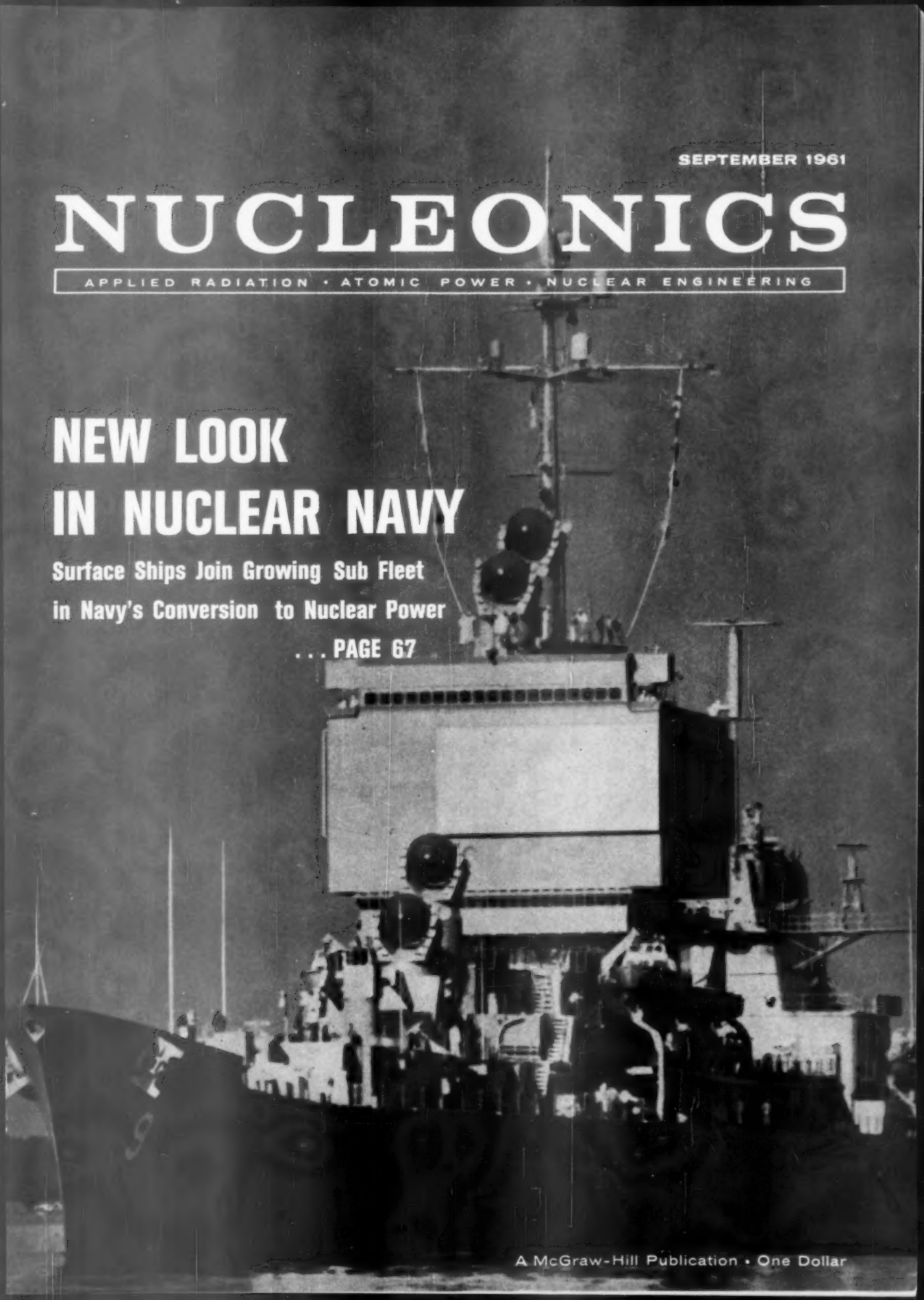
SEPTEMBER 1961

NUCLEONICS

APPLIED RADIATION • ATOMIC POWER • NUCLEAR ENGINEERING



NEW LOOK IN NUCLEAR NAVY

Surface Ships Join Growing Sub Fleet in Navy's Conversion to Nuclear Power

. . . PAGE 67

A McGraw-Hill Publication • One Dollar

X-RAYING LARGEST STAINLESS STEEL "HOT" PUMP CASTING

Above, technicians mark segment of casting for one of many hundreds of X-ray pictures employing a 24,000,000 volt Betatron at the Bonney Floyd Foundry. *Below*, X-ray picture is carefully inspected for flaws.

Shown here is the largest single-piece stainless steel pump casting built today. The X-ray procedure is just one of the many inspections necessary to assure the high quality in Worthington nuclear pumps. Special designs were necessary to allow a single casting to be made for this size pump.

A more complete discussion of special equipment criteria and manufacturing techniques for nuclear requirements is available in a Worthington pamphlet, "Manufacturing For a Nuclear Power Plant." Ask for RP-1092.

To provide the special attention required to engineer and manufacture nuclear products, Worthington has an Advanced Products Division which specializes in pumps and other equipment for nuclear plants. For further information, write Worthington Corporation, Nuclear Department 106-7, Harrison, New Jersey.

WORTHINGTON

PRODUCTS THAT WORK FOR YOUR PROFIT

Hold-down unit locks fuel element to lower grid plate. Another practical reactor development by B&W.

Most reactors call for a spring mechanism to keep fuel elements in place, yet allow for thermal expansion.

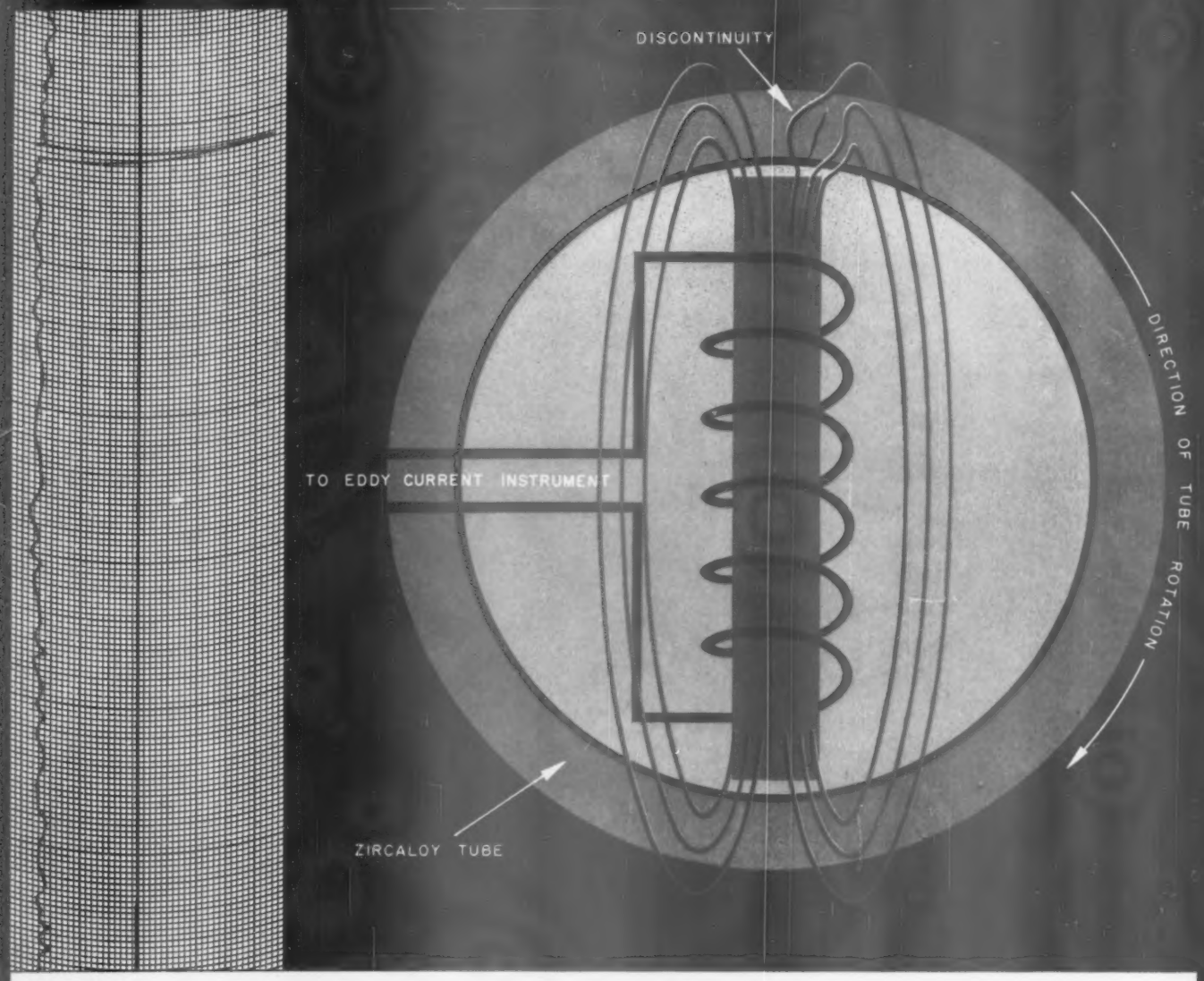
Babcock & Wilcox engineers recently conceived a basic improvement in this system. By locking the fuel elements into the lower grid plate, the "bottom hold-down unit" permits the elements to withstand an increased amount of pressure drop and reduced compression load.

The unique hold-down unit assures positive removal of fuel elements after extended reactor operation under adverse conditions. All moving parts are attached to the fuel element, eliminating complicated replacement problems.

The hold-down unit also cuts the cost of core internals. A full-scale reactor requires only one hold-down unit for every two fuel elements.

The bottom hold-down unit, another practical engineering feature developed in the nuclear laboratories of B&W, can be adapted to many core designs and configurations. For information write to The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, New York. E-701-1002

Babcock & Wilcox



EDDY CURRENT PROBES INSIDE STORY ON PATHFINDER FUEL ELEMENT TUBING

Revealing the inside story on 60,000 tubes for the Pathfinder Reactor assured freedom from cracks greater than 10% of wall thickness on inside diameter.

This schematic end view of a rotating tube and the inserted probe illustrates the eddy current paths. When an inside diameter surface or subsurface discontinuity passes over the probe, changes occur in the electrical value of the coil (impedance). A corresponding change in voltage and current flow within the coil is converted and fed to the chart recorder (left). This probe provides 100% non-destructive testing of the zircaloy tubing.

This semi-automatic, non-destructive test apparatus, devised by T.I.'s scientists, rotates tubing while electronic probe is inserted.

This is an example of quality control applied to Pathfinder fuel elements being manufactured by Metals & Controls Inc., a corporate division of Texas Instruments Incorporated for the Allis Chalmers Manufacturing Company. Similar quality control methods and complete laboratory facilities of our M & C Nuclear Products group are ready to work for you to insure complete integrity of components for your nuclear projects. Our colorful booklet, "Fuels of the Future," is available on request from department NU-9.

METALS & CONTROLS INC.

P. O. BOX 808 • ATTLEBORO, MASS., U. S. A.

A CORPORATE DIVISION OF

TEXAS INSTRUMENTS

INCORPORATED

NUCLEONICS

APPLIED RADIATION • ATOMIC POWER • NUCLEAR ENGINEERING

SEPTEMBER 1961 • VOLUME 19 NUMBER 9

FEATURE ARTICLES

A NUCLEONICS Special Report

67 Surface Ships Join the Subs in Our Growing Nuclear Navy
JOHN E. KENTON

79 Data Sheet No. 43—42 Gamma Spectra of Short-Lived Nuclides
MINORU OKADA

82 Transistor Counting-Rate Channel for Triga Reactors
JOHN H. CAWLEY

INSTRUMENTATION & MEASUREMENTS

88 New Glass is Excellent High-Level Dosimeter; Cerenkov Counter for Fuel-Burst Detection; Variable-Capacitance Strain Gage

90 Slide Rule for Dead-Time Corrections
JAMES H. SCOTT

94 Magnetic Domains Complicate Beta-Backscatter Technique
DON H. JOHNS and ORVAL R. ALEXANDER

NUCLEAR ENGINEERING

99 In-Pile Corrosion of an Aluminum Alloy
NOEL P. SHIELLS, ROBERT O. BOLT and JAMES G. CARROLL

APPLIED RADIATION

104 Hallam Radiation Facility Might Be World's Cheapest

106 Molecular Dissociation in Charge-Transfer Reactions
VLADIMÍR ČERMÁK and ZDENĚK HERMAN

DEPARTMENTS

NUCLEAR REACTIONS	6	PRODUCTS AND MATERIALS	123
NEWS OF THE MONTH	21	NEWSMAKERS	134
NUCLEAR BOOKSHELF	116	NUCLEAR CALENDAR	135

INDEX TO ADVERTISING 138

Jerome D. Luntz, Editor and Publisher

R. Hobart Ellis, Jr., Managing Editor

TECHNICAL STAFF

Thomas L. Cramer, Associate Editor
Harold L. Davis, Associate Editor
James J. Dutton, Associate Editor
Margaret Beach Glos, Assistant Editor

NEWS STAFF

John E. Kenton, News Editor
Robert E. L. Adamson, Associate News Editor
Robert McCluskey, Assistant Editor
John Wilhelm, Manager, News Bureaus
Washington—G. B. Bryant, Jr., Chief, Richard A. Smith; London—John Shinn, John Tunstall; Paris—Robert E. Farrell, Arthur L. Erikson; Bonn—Peter Forbath, Silke B. McQueen; W. Berlin—Hans Plewe; Moscow—Ernest Conine; Tokyo—Sol Sanders; Rio de Janeiro—Leslie Warren; Mexico City—John Pearson; Melbourne—Alicija Grobtuch; Beirut—O. M. Marashian; Brussels—A. P. L. Gordon; Bombay—Sharokh Sabavala; Zurich—Raymond Shah; Johannesburg—Norman Herd; Milan—Gene DiRaimondo; Stockholm—Curt Agren; Vienna—F. H. Baer; Ottawa—Frank Flaherty

PRESENTATION STAFF

Tom Howland, Jr., Art Director
Herbert Taylor, Assistant Art Director
Barbara Keller, Production Editor

●

Philip H. Hubbard, Jr.
Advertising Sales Manager

James H. Thomas, Market Research Manager
James F. O'Brien, Business Manager
Tom Howland, Jr., Promotion Manager
George Pomeroy, Classified Advertising Mgr.

ADVERTISING SALES STAFF

Donald J. Cassidy, New York
Merrill J. Hosmer, Boston
Donald C. Knapp, Philadelphia
Willis T. Smith, Chicago
Thomas K. Cogswell, Cleveland
Frederick R. Whitmore, Los Angeles
Scott Hubbard, Portland
M. Miller, Atlanta
John G. Grant, Dallas
Joseph C. Page, Houston
Jack Patten, Denver
E. E. Schirmer, Dennis McDonald, London
Stanley Kimes, Frankfurt
Michael R. Zeynel, Geneva

●

Thomas L. Cramer, Buyers' Guide Manager
James H. Thomas, Circulation Manager

...about NUCLEONICS

We Go Traveling

Like other Sunday drivers and summer tourists, the NUCLEONICS staff was traveling in recent weeks, separately and in groups. By motorboat we circled the bow of the nuclear-powered cruiser *Long Beach*. By jet we dropped in on two Scottish reactors. By automobile we made one Saturday trip to inspect Nuclear Ship *Savannah*. (We travel all the time—but it's more fun in summer.)

Navy Photography

"And then she left us behind so fast that we couldn't get pictures of her under way on nuclear power," says News Editor John Kenton as he describes the making of our cover picture. As the new cruiser *Long Beach* set out across Boston Harbor, Captain John and his photographer, Gabor Laszlo, bobbed about her bow until the last tug peeled off and the new speed of the great ship made John's 20 knots look like walking. Our thanks go to photographer Laszlo, who is gaining experience in the U. S. before he goes back to resume his career in Sweden.

AUTHOR-PHOTOGRAPHER John Kenton waits on deck for chance to make our cover photo and picture on Page 67

Britain Gets on with It

Another summertime voyage took us (in a busman's holiday for Managing Editor Hobart Ellis) to two quite different nuclear power stations in Scotland: Hunterston, just north of Prestwick on the west coast, and Dounreay, on the northern edge where June sees days that are long enough for midnight cricket.

At Hunterston the present goal is to get the station up and start delivering some 300 Mw of power. As in much of the British economy, delays have resulted from strikes. Thus the two reactors are ~10 months behind what used to be their schedule, but engineers say progress is orderly now, and they hope to deliver power in 1962.

In two 200-ft towers that will someday be reactors one can now enter 70-ft-diameter pressure vessels supported 60 ft above the ground and pipes that will soon carry 150-lb/in², 700°F carbon dioxide. Design is firmly fixed; although Hunterston will watch eagerly as Bradwell and Berkeley go on line, no changes will result. The South of Scotland Electricity Generating Board wants its power.

Meanwhile Dounreay is immersed in experiment and development. Inside the big green sphere of the fast breeder we found men making modifications that will solve gas entrainment problems (NU, Apr. '61, 28; Aug. '61, 24) so that the reactor can go critical again about the time this item is printed. In the nearby testing reactor others are irradiating fuel for later generations of British power reactors. Next door is the Admiralty reactor where Royal Navy men are developing the technology that will one day power British warships.

A McGRAW-HILL PUBLICATION

NUCLEONICS (with which are consolidated "Atomic Power" and "Atomic Engineering"), September, 1961, Vol. 19, No. 9. Published monthly by the McGraw-Hill Publishing Co., Inc., James H. McGraw (1860–1948, founder. Executive, Editorial, Circulation and Advertising Offices, McGraw-Hill Building, 330 W. 42nd Street, N. Y. 36, N. Y. Telephone: Longacre 4-3000. U. S. subscription rate (includes Buyers' Guide issue) for individuals in the field of publication: $8 per year; $12 for 2 years; $16 for 3 years; single copies, $1. For subscription details and Canadian and foreign rates see p. 6. Printed and second-class postage paid at York, Pa., U. S. A. Title registered in U. S. Patent Office. © Copyright 1961 McGraw-Hill Publishing Co., all rights reserved. Officers of the Publication Division: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John C. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator; Daniel F. Crowley, Vice President and Controller. Officers of the Corporation: Donald C. McGraw, President; Hugh J. Kelley, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Executive Vice President and Treasurer; John J. Cooke, Vice President and Secretary.
Postmaster. Please send form 3579 to Fulfillment Manager, NUCLEONICS, 330 W. 42nd St., N. Y. 36, N. Y.

STRONTIUM TITANATE — A unique fuel form developed at Martin's nuclear division through chemical research

The expanding use of radioisotope fueled thermoelectric generators depends largely on the development of suitable isotope fuel forms for the operational and safety requirements of each new system.

For example, the automatic weather station developed by Martin for use in remote geographic locations uses strontium-90 fuel. In order to be used for the weather station, the strontium-90 had to be in a form that provided safety and high performance under all conditions. Although primary protection is provided by housing in a Hastelloy-C corrosion resistant container, the fuel had to be sufficiently insoluble so that biological contamination would be avoided in event of accidental immersion in the sea or other similar accidental loss.

Since the fuel capsule operates at 1000°F, it was also necessary for the chemical fuel form to be stable at this relatively high temperature. A compound in which the concentration of strontium was as high as possible was required to achieve high power density.

Several years ago the Nuclear Division of The Martin Company, which was already engaged in the development of various radioisotope fueled devices, initiated a research program aimed at developing more useful fuel forms for several isotopes. The development of strontium titanate, in collaboration with the USAEC's Office of Isotopes Development, was an early product of this program. It has been fully tested and possesses the characteristics shown on the chart below. The AEC now supplies $SrTiO_3$ as one chemical form of Sr-90.

Radioactive strontium titanate is prepared in remotely operated equipment by precipitating $SrCO_3$ in the presence of TiO_2, calcinating the admixture at 1200°C, compacting the calcination product at 5 tsi pressure, and sintering the green pellets at 1400°C.

Martin Company sponsored research presently includes investigation of the preparation, crystal structure and solubility characteristics of this class of "oxygen-cage" compounds. Other developments in nuclear chemistry at Martin's Nuclear Division include preparation and chemical purification of curium-242 and its conversion into high melting point compounds, and the development of more useful forms of such isotopes as cobalt-60, cesium-137, and cerium-144.

Radioisotope fueled weather station developed and built for the U.S. Atomic Energy Commission by The Martin Company for use in remote geographic locations. Using strontium titanate fuel, heat generated by decay of the Sr-90 isotope will be converted by a thermoelectric generator to trickle-charge the batteries used to transmit periodic reports. The generator is shown being lowered into place for proof-tests which were conducted in Baltimore. The station was shipped in July for further tests under operational conditions in the arctic regions of northern Canada. The system will be capable of remaining in operation for years unattended and without maintenance.

Properties of Strontium Titanate

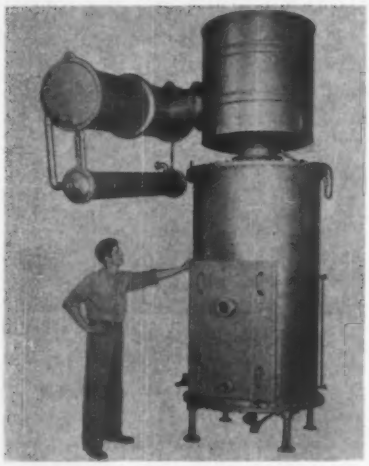
Chemical Formula:	$SrTiO_3$
Melting Point:	3000°F
Practical Density:	4.5 gm/cc
Specific Power:	6.3 watts/kilocurie Sr-90
Power Density:	0.5-1.0 watt/cc $SrTiO_3$*

*Dependent on isotopic purity of fission product and degree of compaction of titanate.

Rate of Solution:	5.5×10^{-4} gm/cm²/year*

*In sea water at 65° C, as measured by tracer techniques with compacted pellets.

MARTIN



FOR HIGHEST PURITY AT LOWEST COST

Whether your requirements are for a ½ gallon or 1000 gallons per hour . . . Barnstead Stills will produce the highest purity distillate at the lowest operating cost.

Although Barnstead "stocks" many standard models, its engineers are specialists in designing the precise Still to meet your exacting purity requirements and operating specifications. Their store of pure water experience goes back to 1878, and since that time 85,000 installations all over the world attest to Barnstead long, trouble-free service life.

Barnstead engineers can match any purity requirement. Need pure water of 1 to 5 megohms electrical resistance? Want freedom from organics, inorganic particles . . . 0.1 or less parts per million total ionized solids? This is purity . . . purer than any other distilled water obtainable. Put Barnstead's experience to work for you. Let us hear from you regarding your Water Purification problem.

WRITE FOR LITERATURE

☐ CATALOG "G" ON WATER STILLS
☐ CATALOG 160 ON DEMINERALIZERS

Barnstead
STILL AND STERILIZER CO.
34 Lanesville Terrace, Boston 31, Mass.

NUCLEAR REACTIONS

Irradiate Potatoes or Not?

DEAR SIR:

Contrary to the impression created by your recent article on food irradiation in France (NU, June '61, p. 23), there has been considerable work in the United States on sprout inhibition of potatoes by low-dose irradiation. The results of this work and related developments form a good basis for the implied reluctance of the American Food Industry to utilize potato irradiation. This reluctance is apparently shared by the Quartermaster Corp (Large Radiation Sources in Industry, Conference Proceedings, Warsaw, IAEA, Vienna, 1960, p. 13).

The facts as best as I can ascertain them are as follows:

1. Certain varieties of potatoes are per se quite resistant to sprouting if stored properly. For example, Russet Burbanks stored at 41°F showed no sprouting for nine months.

2. Chemical sprout inhibitors have been developed during the past few years that now have or are about to receive FDA approval. These will prevent sprouting at least long enough to permit year-around operation of processing plants and to furnish fresh potatoes during those times of the year when there is a market for them.

3. One or another of these chemicals can be applied by crop dusting prior to harvest, by spraying during transfer to storage or by injection into the ventilation system of the storage cellar.

4. Cost of applying the chemical inhibitors is no more than 5¢ per 100 wt.

5. Irradiation reduces the wound-healing tendency of bruised potatoes and increases storage rot. To permit healing of harvest-incurred bruises, irradiation would be most effective several weeks after harvest (as in the French tests).

6. In your article the cost of such irradiation is quoted only as less than 50¢ per 100 wt. It has been estimated at a minimum of about 16¢ per 100 wt in the United States and Canada.

7. To achieve even this cost requires an irradiator operating year around, mounted on a railroad flatcar. Aside from economics there are thus some factors severely reducing the flexibility of irradiation as compared to chemical treatment.

—GEORGE A. FREUND
President
Western Nuclear Corp.
Idaho Falls, Idaho

[*Editor's note. The article referred to was a report on the French activities in irradiation of potatoes and was not intended to report on U. S. activities.*]

Credit for Irradiation Ship

DEAR SIR:

I was pleased to read the article "Irradiation Ship Would Eliminate Grain Loss to Insects in Tropics," based on a proposal by Tom Horne and myself, that appeared in the June issue of NUCLEONICS, but regret that credit was not given to James Sickles and Kei An Lee, graduate students in nuclear engineering at the University

Subscription Information

Subscription rates (includes Buyers' Guide issue): United States $8 per year; $12 for 2 years; $16 for 3 years. Canada, other Western Hemisphere countries, and the Philippines, $10 for 1 year; $16 for 2 years; $20 for 3 years; all other countries, $15 for 1 year; $25 for 2 years; $30 for 3 years. Single copy prices: United States, U. S. possessions and Canada, $1, elsewhere, $2; Buyers' Guide issue $2 and $4.

Nucleonics is available only by paid subscription. Publisher reserves the right to refuse nonqualified subscriptions. Subscriptions to Nucleonics solicited only from individuals engaged in the design, development and use of atomic power, nuclear engineering and applied radiation. Position and company connection must be indicated on subscription orders.

Subscription correspondence and changes of address should be sent to Fulfillment Manager, Nucleonics, 330 W. 42nd St., New York 36, N. Y. Allow one month for change of address, giving old as well as new address, and including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Please allow one month for change to become effective.

Our primary aim is to provide subscribers with a useful and valuable publication. Your comments and suggestions for improvement are encouraged and will be most welcome. If editorial service is unsatisfactory, the publisher, upon written request, agrees to refund the part of the subscription price applying to the remaining unfilled portion of the subscription. Printed in U. S. A.

Title registered in U. S. Patent Office. Copyright 1961 McGraw-Hill Publishing Co., all rights reserved.

of Michigan, who worked out the design for the ship irradiator. The reference to grain losses in the U. S. "as high as 50% per year" should not be misconstrued as the weight per cent loss to insects; it rather refers to the dollar-value loss. When insect contamination exceeds the maximum value allowed by FDA, grain intended for human consumption (~$3/lb) must be used for animal feed. The value of grain for feed is closely related to the value of corn—often ~50% of the value of wheat used for milling. On the other hand, the chairman of the IAEA symposium put the worldwide losses at enough to feed 400 million people a year rather than 100 million people mentioned in the article as the estimate of the UN Food and Agricultural Organization.

—L. E. BROWNELL
Department of Chemical and Metallurgical Engineering
University of Michigan

Thermal Conductivity Increase above 1,600°K

DEAR SIR:

I have noticed two typographical errors in my article "Thermal Conductivity of UO_2 Improves at High Temperatures" in June NUCLEONICS.

1. The label on the curve in Figure 2, page 84, should be $16\sigma n^2T^3/3\alpha$.

2. The units of k, in the table of nomenclature on page 84 should read watt/cm °K rather than watt-cm/°K.

We have recently completed the examination and evaluation of three fuel cores irradiated with high central-core temperatures and with large radial temperatures. Using the same concepts as those in my article, we found a similar increase in the thermal conductivity of UO_2 above 1,600°K.

—J. LAMBERT BATES
Hanford Atomic Products Operation
General Electric Co.
Richland, Wash.

Correction to 1960 Reference Manual

DEAR SIR:

I have noted a mistake on page 168 of the NUCLEONICS 1960 Reference Data Manual. The equation for temperature distribution for a cylindrical shell for the conditions $t = t_0$ at $r = r_0$ and $dt/dr = 0$ at $r = r_1$ should read

$$\frac{t - t_0}{P} = 1 - \left(\frac{r}{r_0}\right)^2 - \left(\frac{r_1}{r_0}\right)^2 \ln\left(\frac{r_0}{r}\right)^2$$

—W. MARKERT, JR.
Babcock & Wilcox Co.
Alliance, Ohio

CHECK THESE CAPABILITIES!

RCA

FACTORY-TRAINED SERVICE SPECIALISTS *provide*

Nationwide *On-Site* Maintenance and Calibration for All American-Made Nuclear and Scientific Instruments!

✓ INSPECT
Skilled services performed at your facility by specialized personnel from nearest RCA repair center . . . to save you time and money!

✓ DETECT
RCA nuclear and scientific service specialists factory-trained by major equipment manufacturers . . . to find the trouble fast!

✓ CORRECT
Extensive stock of factory-specified replacement parts and portable servicing gear carried by RCA specialists . . . to ensure reliable replacements and conclusive, dependable service!

E. G.
Fort Belvoir reactor training simulator . . . normally in operation 24 hours a day . . . no regularly scheduled maintenance time . . . maintained by RCA on yearly contract basis . . . results: *better than 99 per cent of scheduled training time is productive time!*

Realizing the increasing importance of nationwide service facilities, many prominent manufacturers* of nuclear and scientific equipment have contracted with RCA Service Company as an approved service representative for their products.

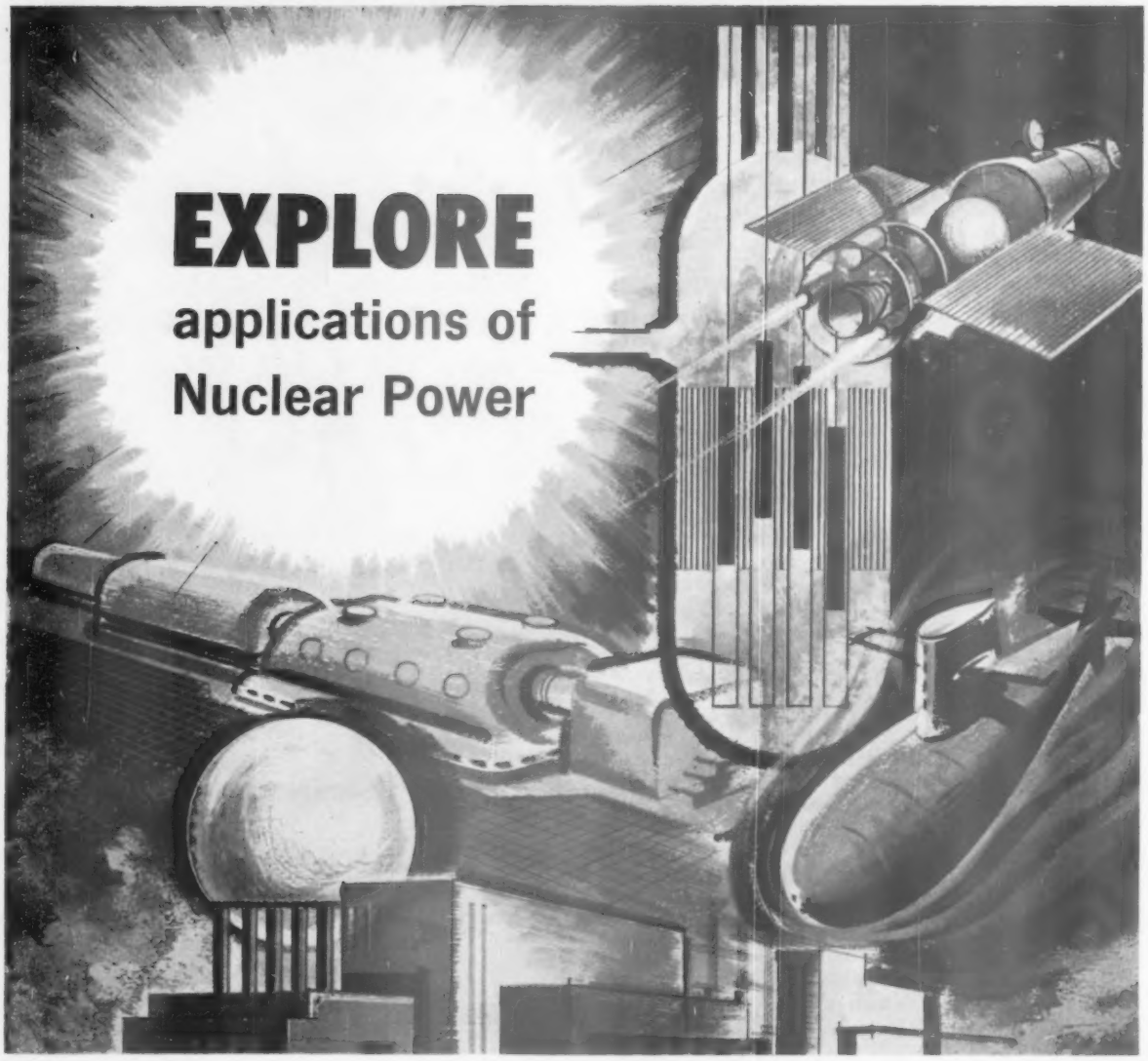
RCA can serve you skillfully in these areas:

- **Equipment installation and maintenance**
- **Complete facility operation**
- **Specialized engineering assistance**
- **Training and publications**

For additional information on RCA services, phone WOodlawn 3-8000, Ext. PY 6038, or write to RCA Nuclear and Scientific Services, Bldg. 206-2, RCA Service Company, Cherry Hill, Camden 8, N. J.

*Names available upon request

RCA
The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA



A broad program to explore applications of nuclear power is actively underway at the Research Laboratories. Current projects include performance and cost studies of nuclear power systems for interplanetary space vehicles, small mobile electric power generating plants, and commercial central power stations. Programs are also underway to explore the uses of radioisotopes. Specific areas in which openings exist are described below:

Breeder reactors — nuclear engineer or engineering physicist to establish performance and physical characteristics of advanced breeder reactors for application to central power stations. Advanced degree in nuclear engineering or physics required.

Power conversion — mechanical engineer for thermodynamic cycle analyses and preliminary design of power conversion cycles for use with advanced high-temperature reactors. Advanced degree in mechanical engineering required.

Radioisotopes — nuclear engineer to develop programs for the application of radioisotopes to various research investigations and industrial processes. Advanced degree in nuclear engineering required.

Reactor criticality and control — nuclear engineer to perform criticality and control studies of advanced reactors of novel design for nuclear rocket propulsion systems. Advanced degree in nuclear engineering required.

Fuel cycles — nuclear-chemical engineer to conduct studies to establish fuel compositions for power reactors which optimize reactor performance and minimize fuel recycle cost. Advanced degree in chemical engineering required.

Advanced reactor concepts — reactor physicist or nuclear engineer to originate preliminary designs suitable for chemo-nuclear, direct fission-electric, and other applications. Opportunity for parallel research in fundamental problems of nuclear physics. Doctoral level of experience required.

This program is corporate-sponsored and of the long-range sustained type. Thus, it offers a high degree of security in addition to excellent advancement opportunities. Salaries are at a level that will interest mature men of demonstrated ability.

If you have an appropriate scientific or engineering degree and experience, we invite an early inquiry. Please write in confidence to Mr. W. R. Walsh.

RESEARCH LABORATORIES
UNITED AIRCRAFT CORPORATION
400 Main Street, East Hartford 8, Conn.

All qualified applicants will be given consideration for employment without regard to race, creed, color, or national origin.

PECHINEY

FIRST
WITH TWISTED FINS
BERYLLIUM TUBES

A MILESTONE IN BERYLLIUM TECHNOLOGY

PECHINEY aims at supplying the Nuclear industry with the very best products.
Graphite, beryllium, beryllium oxide, niobium, zirconium, thorium, key materials in the nuclear field are available pure, alloyed, machined.

Apply for literature.

PECHINEY

Division "Applications Atomiques et métaux spéciaux".
23, rue Balzac - PARIS 8e - CARNOT 54-72

Son, we call this
a "Fisher"

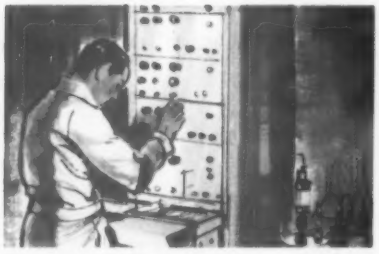
The worthiness of a name

In refineries, chemical plants, and oil fields, many "old timers" associate the name "Fisher" with high quality control valves and liquid level controllers. Through the years, in their work on instruments and controls, they have come to know that "Fisher" means dependability.

"Put a 'Fisher' in the line, and forget it." they would always say.

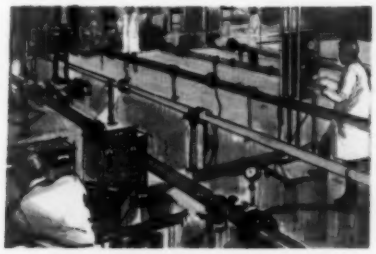
The quality found in Fisher equipment lies not only in metal and fiber and paint. It is also found in the practical design, manufacturing techniques, and the rigid inspection program. These high quality factors along with outstanding research and engineering facilities assure you of trouble-free performance. Throughout the world, "Fisher" means dependable control equipment.

FISHER GOVERNOR COMPANY *Marshalltown, Iowa / Woodstock, Ontario / Rochester, England*



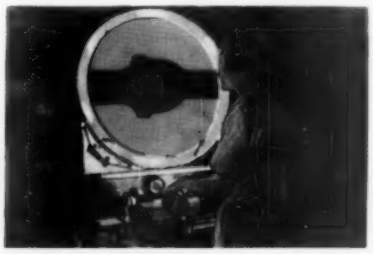
Continuous Advanced Research . . . Fisher research maintains a continuous program for development and use of new metals and materials to meet the increasingly severe conditions, encountered daily, in the nuclear and cryogenics fields.

Engineering and Research . . . Almost three-fourths of Fisher's 41 graduate engineers have more than 10 years service . . . a total of 380 years experience in design engineering aimed at solving industry's flow control problems, practically and efficiently.



Testing and Development . . . Representative of the very latest and finest in equipment that aids Fisher engineers in the development of new and improved products is the recent addition of a test line that is capable of handling air or water pressures up to 2,500 psi.

Latest Production Methods . . . Various new style grinders produce a super-finish on Fisher valve guides and bushings, second to none in the industry. It is typical of precision manufacturing methods that assure long, trouble-free operation of Fisher controls.



Rigid Inspection Procedures . . . The highest ratio of inspection personnel to production personnel in the industry is maintained at Fisher. As an example, there are no less than 704 inspection operations on a 4" Type 657-A diaphragm control valve.

Efficient and Fast Service . . . "Supermarket" 36-hour delivery, from the factory, on popular sizes and types of controls is only one of many services available to Fisher customers. Seventeen sales offices throughout the country maintain field stocks for immediate delivery.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER®
Controls
SINCE 1880

HARSHAW CRYSTALS are 1728 TIMES LARGER than 25 years ago

with "Harshaw Quality" inherent in each crystal

This year Harshaw's Crystal Division celebrates its Silver Anniversary. In these 25 years the "art" of growing crystals has given way to scientific procedures. With expanded crystal research and development laboratories, and recently doubled production facilities, Harshaw stands ready to produce your crystals—regardless of technical nature or production magnitude. Our physics, chemistry, and engineering departments enjoy the challenge of increasingly stringent demands from scientists and instrument manufacturers for infrared and ultraviolet optical crystals, and scintillation phosphors.

OPTICAL CRYSTALS

For Infrared and Ultra Violet Transmitting Optics

- Sodium Chloride
- Sodium Chloride Monochromator Plates
- Potassium Bromide
- Potassium Bromide Pellet Powder (through 200 on 325 mesh).
- Potassium Chloride
- Optical Silver Chloride
- Thallium Bromide Iodide
- Lithium Fluoride
- Lithium Fluoride Monochromator Plates
- Calcium Fluoride
- Barium Fluoride
- Cesium Bromide
- Cesium Iodide

SCINTILLATION

Mounted NaI (Tl) Crystals

Crystal detectors designed for your most sophisticated counting problems. Our physics and engineering groups are available to assist you.

- Other Phosphors—Rough Cut Thallium Activated Sodium Iodide Crystal Blanks
- Europium Activated Lithium Iodide (Normal)
- Europium Activated Lithium Iodide (95% Li^6 Enriched)
- Thallium Activated Cesium Iodide
- Thallium Activated Potassium Iodide
- Anthracene
- Plastic Phosphors

Write for our 36-page booklet "Synthetic Optical Crystals" or our 44-page booklet "Scintillation Phosphors"

The Harshaw Chemical Company Crystal Division

1945 East 97th Street • Cleveland 6, Ohio

Utrecht, Netherlands—Contact Harshaw-Van Der Hoorn N. V., Juffaseweg 186

Guide to a space ride

Inland DC torque motors are integral components of many major U.S. missile guidance and ground support control systems. These direct-drive torquers provide efficient, low speed operation and produce exceptionally high torque to power ratios. Their gearless, pancake design eliminates backlash and other problems inherent in conventional motor design.

Inland products are used in various space instrumentation systems. For example:

- DC torque motors and rotary amplifiers are utilized in tracking antennas for Project Mercury.
- For a space exploration mission, Inland torque motors will help keep solar energy cells constantly aimed at the sun.
- For a new satellite, Inland torque motors and tachometer generators will keep cameras in constant focus on the earth.

Inland Motor Corporation is a subsidiary of Kollmorgen Corporation. Both coordinate their efforts in the design and production of instruments and systems involving optics, mechanics and electronics for industry and defense. For literature, Write Dept. 2-9

Resumes invited from qualified optical engineers.

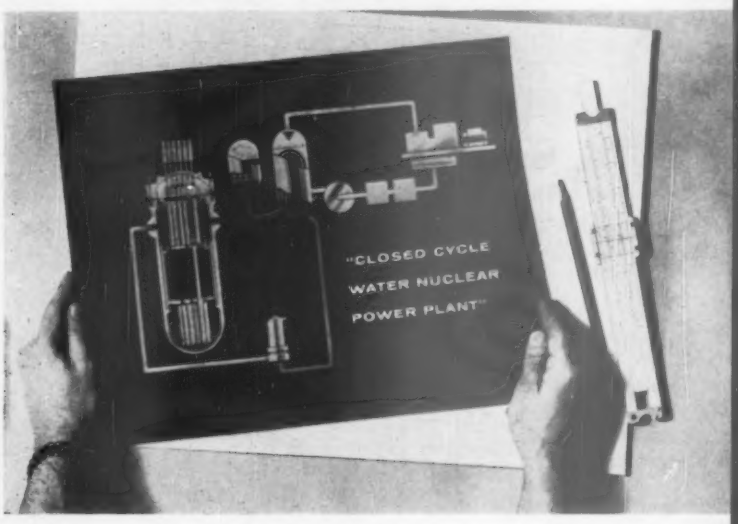
K C **KOLLMORGEN**
CORPORATION
NORTHAMPTON, MASSACHUSETTS

ON THE LINE

Yankee—a Westinghouse achievement of the first order in its continuing effort to bring atomic power to its full commercial capabilities.

ON THE BOARDS

the new 375-Mwe atomic power plant is a giant step forward in the realm of controlled commercial nuclear power. Projects like this offer to professional personnel the opportunity to take part in the design and development of economic nuclear power plants. Career openings for qualified scientists exist in many areas. Some of these areas are listed in the next column.



Westinghouse

FIRST IN ATOMIC POWER

ATOMIC POWER DIVISION

PHYSICIST:

Capable of independent work in reactor physics, to direct research and development on advanced reactor concepts, or to perfom and direct reactor physics and nuclear design work on cores nearer completion.

SENIOR STRESS ANALYST:

To conduct test programs for the analysis of stresses in reactor components with emphasis on thermal stresses due to internal heat generation. Requires an M.S. or Ph.D. degree in Applied Mechanics or a closely related field with 3 or more years experience in stress and vibration analysis. Should have experience in plasticity and fatigue analysis and a familiarity with reactor materials and their behavior.

SENIOR ENGINEER:

Alloy development on reactor materials and fuels with particular emphasis on control rod and cladding materials. M.S. degree in metallurgy with three years experience in reactor materials.

ENGINEER:

To perform analyses and detail specifications of fuel cycle requirements for WTR; to perform analyses of experiments to be inserted in the reactor. Must be able to determine reactivity losses associated with fuel depletion and experiments inserted or removed from the reactor. These analyses will include neutron flux perturbation, power production and safety analysis of experiments and their effect on the reactor. Must possess a B.S. in reactor engineering or an M.S. in physics with two years experience in nuclear design of reactors.

ENGINEER OR SCIENTIST:

To perform reactor physics calculations on reactor cores which involve problems of the development and application of theoretical methods, founded on basic theory, to technical programs concerned with the design and construction of large power reactors. M.S. degree in physics or nuclear engineering.

SCIENTIST:

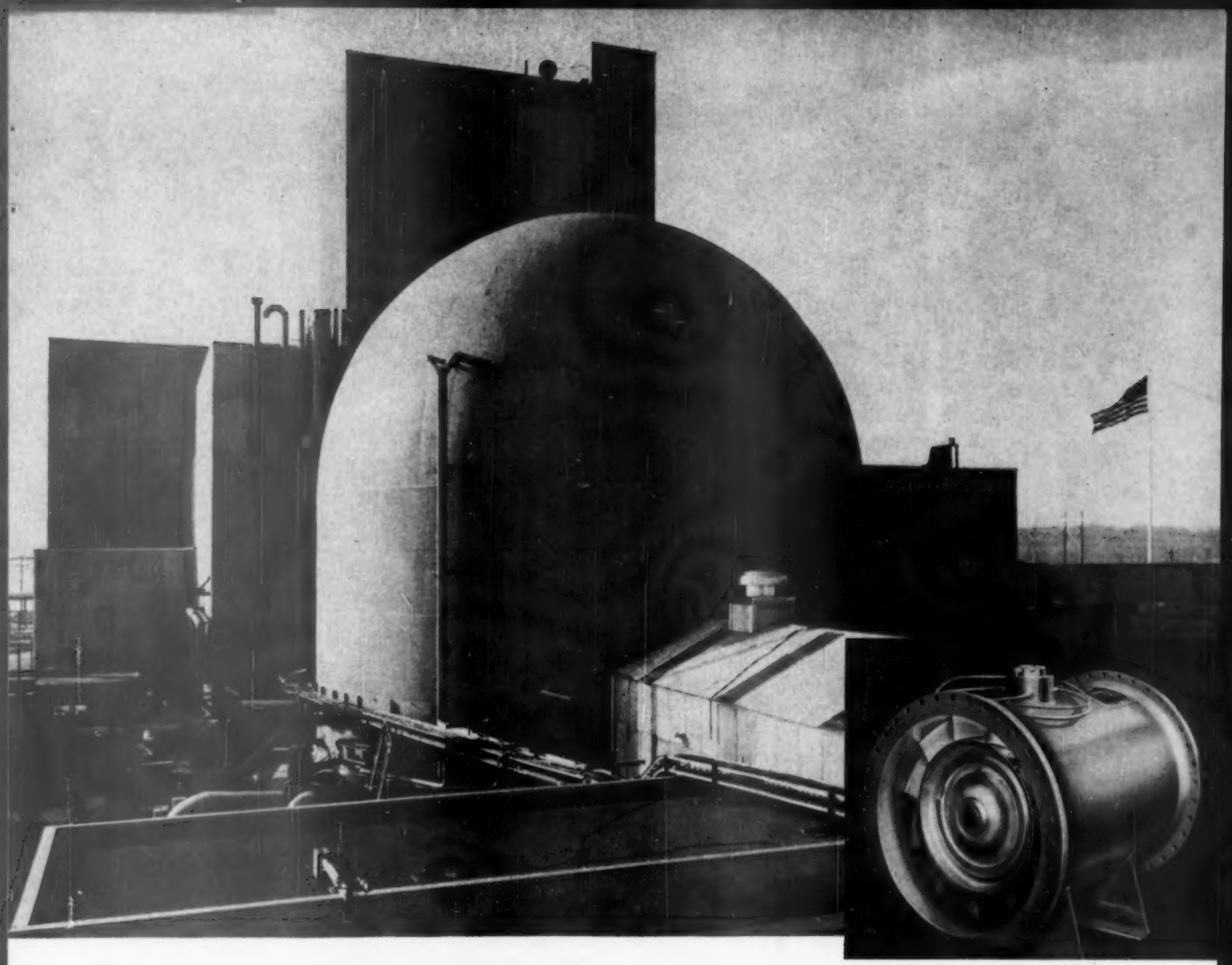
Involves the mathematical analysis of problems in reactor physics and engineering with emphasis on the development of digital computer programs or adaptation of existing programs to meet special requirements. B.S. degree in mathematics, physics or engineering with emphasis on applied mathematics and experience in digital computer applications.

MANAGER PHYSICAL METALLURGY SECTION:

The position requires a man well rounded in the fundamentals of physical metallurgy. Experience with the effects of radiation on metals both fuel bearing and non-fuel bearing desired. The position will also involve stainless steel and carbon steel alloy development and development in the field of other high temperature metals and ceramics such as graphite, beryllia or other ceramics used in the nuclear industries. A strong foundation of physical chemistry is desirable since there will be problems concerning corrosion. Should be able to assist project design engineers in problems regarding the fatigue, creep and brittle fracture of metals and alloys. Ph.D. or equivalent required.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

If you qualify for any one of the above positions, write immediately to: Mr. C. S. Southard, Westinghouse Atomic Power Division, P. O. Box 355, Dept. Y-17, Pittsburgh 30, Pa.



Two-stage JOY Axivane® Fans provide lower vessel ventilation at Enrico Fermi Atomic Power Plant

A special two-stage Joy Axivane Fan circulates the enclosed nitrogen atmosphere which provides lower vessel cooling for the world's largest fast neutron breeder reactor. Rated at 100,000 KW, the Enrico Fermi plant built by Power Reactor Development Company and The Detroit Edison Company will be among the largest atomic power plants in operation. In addition to handling the critical lower vessel cooling, Joy also provided the heavy duty fan for dilution of stack gas.

Joy Axivane Fans are ruggedly built to meet the most demanding service requirements. Power consumption is held to a minimum, because Joy Axivane Fans have adjustable pitch blades which can be set for any desired volume of air over a wide range. Drive motors can always be operated at their most efficient speed. To conserve space and cut installation costs, these fans can be mounted directly in the duct—motors are integral. V-Belt drive is available if desired.

Whenever you need heavy duty, economical ventilation fans, consult your Joy representative. For complete information on Joy fans, write for Bulletin 2549-92

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Tomorrow's tubing technology—today

Superior fuel element tubing —custom-tailored to reactor designs

All Superior nuclear-quality fuel element tubing is custom-made to fit the specific requirements of reactor applications. High standards of quality and extremely close tolerances demand such exacting workmanship. Here are some of the important steps Superior takes to assure a high level of reliability in the finished product.

MATERIALS: We offer nuclear-quality tubing in Types 304, 304L, 316, 347 and 348 stainless steel; also in Inconel,[1] Zircaloy 2,[2] Zircaloy 4,[2] columbium and 1% zirconium-columbium alloy. We can supply these grades with closely controlled chemical composition.

RAW STOCK: Only high-quality tubing hollows are selected, and statistical sampling is performed to provide stock with the most uniform dimensions. Since wall uniformity is paramount, Vidigage inspection can be used to check the wall dimension over the entire length of tubing, when desired. This equipment can be used for both in-process and finished product inspection, and a recording device can be attached to locate thin spots so they can be eliminated.

IN-PROCESS INSPECTION: We check tubing for general surface appearance and size routinely. (More and more it is becoming a requirement that fuel element tubing be air gaged over the entire length during the straightening operation to assure the close tolerances needed.)

FINISHED QUALITY: Ovality and inside dimension can be held to much closer tolerances than standard mechanical tubing. This is accomplished by use of air gage inspection. For example, we have produced fuel element tubing as small as .060 in. ID with a tolerance held to ±.0005, including ovality.

CUT LENGTHS: Cut lengths can be supplied with square cut ends held within .002 in. This, with extremely close control of other dimensions, permits us to offer fuel element tubing ready for pellet loading.

CLEANLINESS: Inside surfaces are bright, free of discoloration, dirt and other foreign matter. Each tube can be individually packaged with ends of the tubing capped to provide extra protection in transit and storage.

CERTIFICATION: A certificate of compliance is provided to assure that the tubing supplied meets your specifications.

NONDESTRUCTIVE TESTING: The following tests are performed when required. *Eddy Current*—Tubing with wall from .010 to .040 in. can be processed with a defect level of 10% of the wall being cause for rejection. Walls heavier than .040 in. are rejected if they have a defect greater than 3% of the wall or .004 in. deep. *Ultrasonic*—The same defect level as eddy current applies; however, tubing of less than 5/16 in. OD cannot be processed on this equipment. *Autoclave Corrosion Test*—Performed on tubing produced from the reactive metals such as Zircaloy 2 and Zircaloy 4 to specification. Either water or steam is used for a 3- or 14-day period. Typical temperature is 350°F at 15,000 psi pressure. *Helium Leak Test*—We are capable of performing this test on a 100% basis to customers' specification. A typical rejectable leak rate is 1×10^{-8} cc/sec.

[1] Reg. TM of International Nickel Co.
[2] Reg. TM of Westinghouse Electric Corp.

If you need either heat exchanger tubing or fuel element tubing, consult us. Our extensive facilities and TubeXperience in the production of these close tolerance tubes are at your service. Write us about your specific requirements. Superior Tube Company, 2027 Germantown Ave., Norristown, Pa.

Superior Tube (ST)

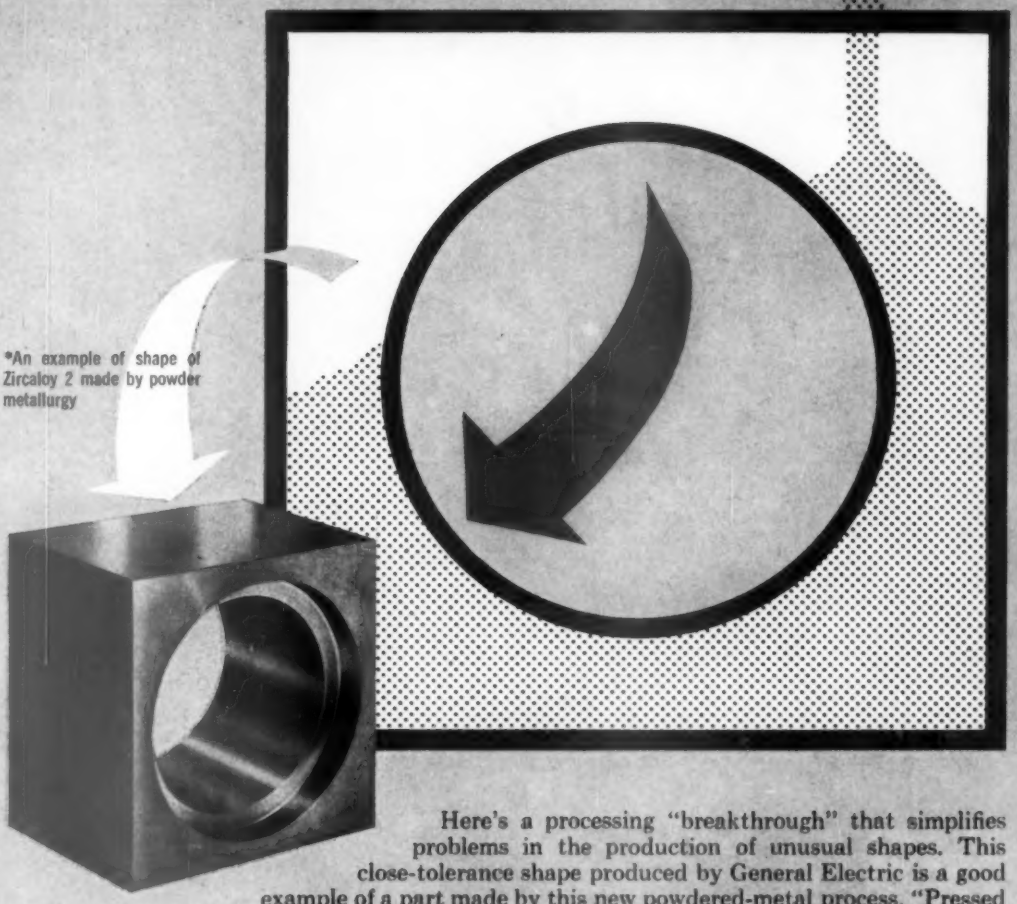
Norristown, Pa.

THE BIG NAME IN SMALL TUBING

West Coast: Pacific Tube Company, Los Angeles, California

G-E ZIRCALOY 2*

"Pressed-to-shape" metallurgy process slashes machining cost



*An example of shape of Zircaloy 2 made by powder metallurgy

Here's a processing "breakthrough" that simplifies problems in the production of unusual shapes. This close-tolerance shape produced by General Electric is a good example of a part made by this new powdered-metal process. "Pressed to shape" means machining costs are reduced appreciably and expensive metal waste is saved. Low gas content and high density are assured by the process. The corrosion resistance and low-neutron cross-section properties of the metal are highly desirable for nuclear and chemical applications. Zircaloy 2 is now available from General Electric in shapes and billets. Write for full particulars.

METALLURGICAL PRODUCTS DEPARTMENT

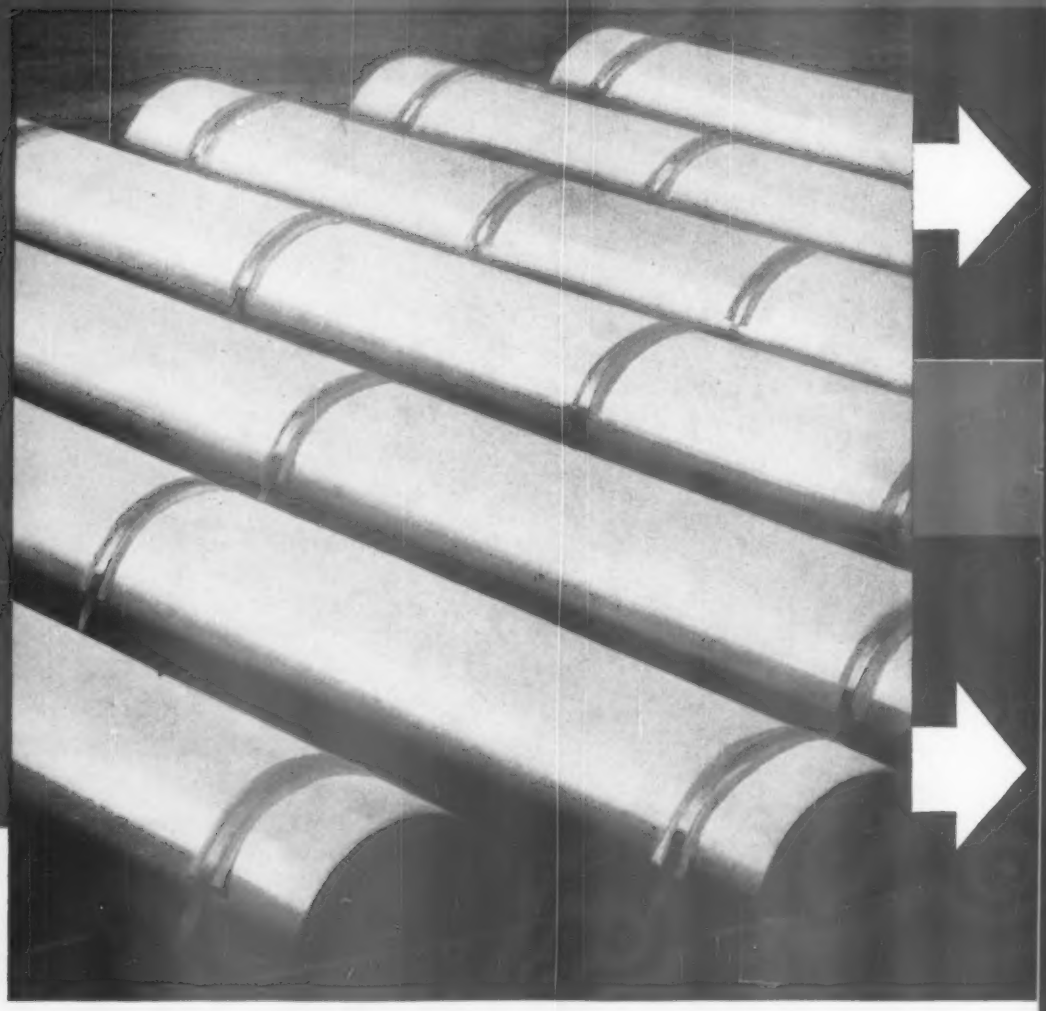
GENERAL ELECTRIC

11135 E. 8 Mile Blvd., Detroit 32, Michigan

Carboloy® Cemented Carbides • Man-Made Diamond • Magnetic Materials • Thermistors • Thyrite® • Vacuum-Melted Alloys

new nuclear plants choose

FULFILLS THE EXACTING HEAT EXCHANGERS



Centrifugal stainless steel castings readied for shipment by U.S. Pipe

The Government's new SPERT III nuclear plant at the National Reactor Station near Idaho Falls, Idaho, operating since December, 1958 to study nuclear reactor safety, uses U.S. Pipe's centrifugally cast stainless steel pipe for its coolant system.

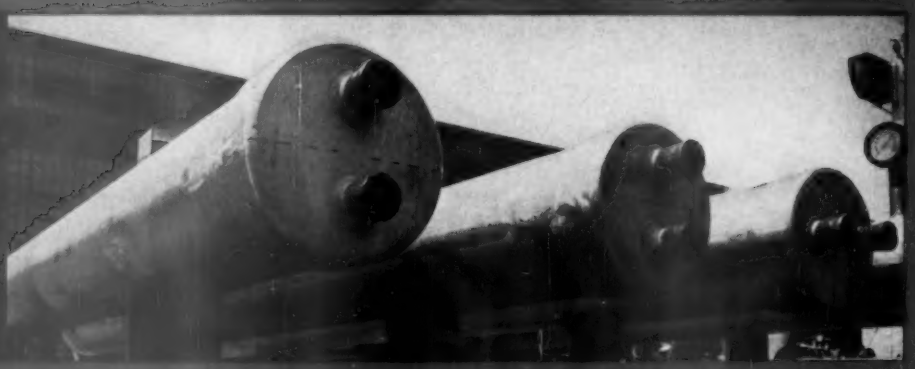
SPERT III is classified as a high pressure, high temperature, light water moderated and cooled reactor. Its versatility permits transient tests under various initial conditions of pressure, temperature, and coolant flow. For example, pressures ranging from atmospheric to 2,500 psi and water temperatures from 68° to 668° F.

Another new nuclear power plant, engineered and constructed by Stone & Webster for Yankee Atomic Electric Company, is using centrifugally cast stainless steel heat exchanger shells made by U.S. Pipe and fabricated by the Southwestern Engineering Company in Los Angeles, Calif.

Stainless steel, centrifugally cast, made to rigid specifications, may be the answer to your piping or heat exchanger problem. For more information, write or call:

centrifugally cast stainless

REQUIREMENTS OF NUCLEAR AND COOLANT SYSTEMS



Shop-fabricated heat exchanger shells of centrifugally cast stainless steel ready for shipment to the Yankee Atomic Electric plant at Rowe, Mass.

Subassemblies of primary coolant piping of centrifugally cast stainless steel being installed in SPERT III.

ASA PRESSURE PIPING CODE STATUS

Approval has been granted under this code for the use of centrifugally cast austenitic pipe for nuclear piping by Nuclear Case N-9. This case appeared in the April, 1960 issue of MECHANICAL ENGINEERING. Reprints on request.

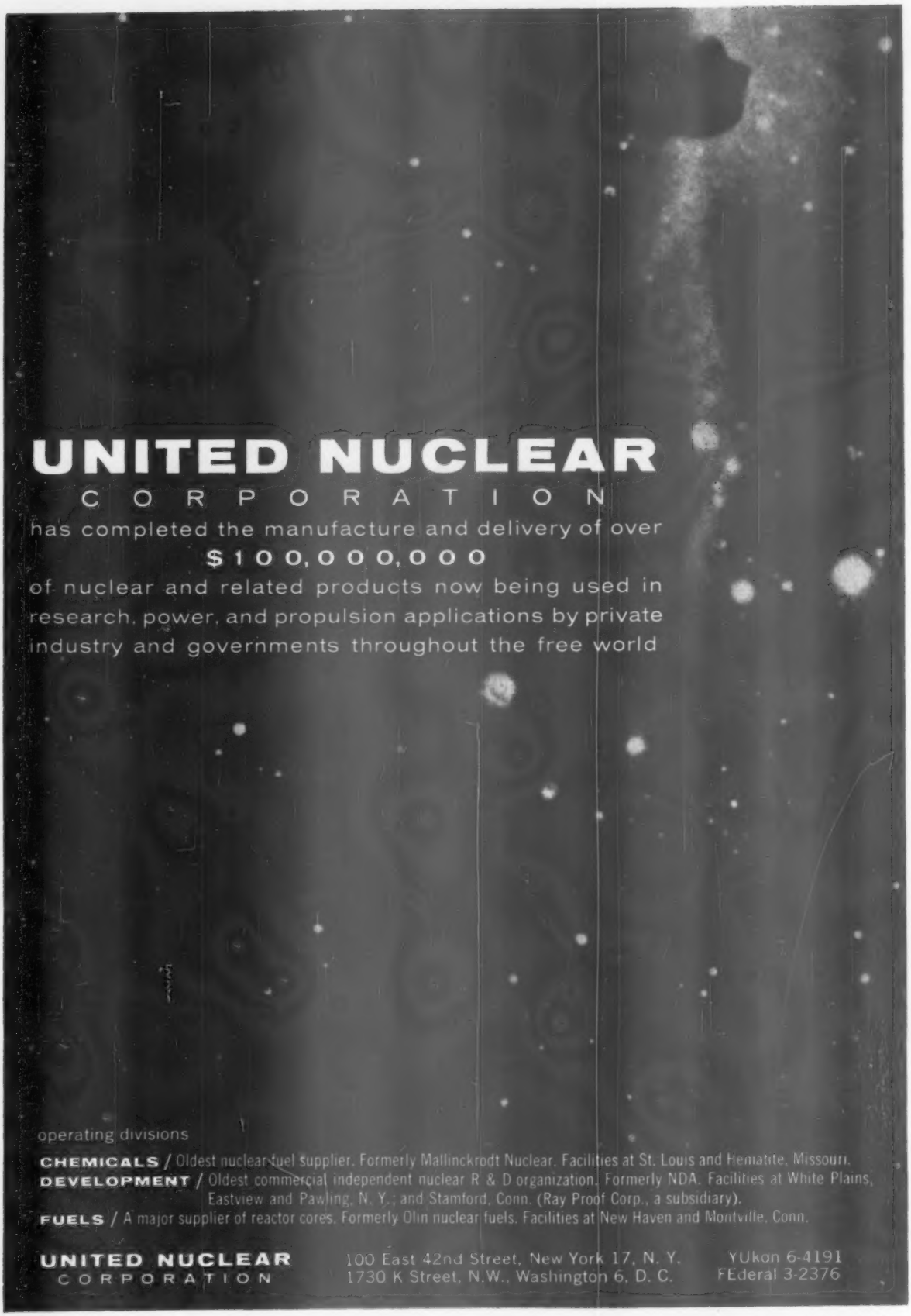
UNITED STATES PIPE & FOUNDRY CO.

Steel and Tubes Division

STEEL & TUBES U.S. PIPE DIVISION

BURLINGTON, NEW JERSEY

SALES OFFICES: BURLINGTON, BOSTON, BIRMINGHAM, CHICAGO, CLEVELAND, DALLAS, LOS ANGELES, NEW YORK, PITTSBURGH, SAN FRANCISCO


UNITED NUCLEAR
CORPORATION
has completed the manufacture and delivery of over
$100,000,000
of nuclear and related products now being used in research, power, and propulsion applications by private industry and governments throughout the free world
operating divisions
CHEMICALS / Oldest nuclear-fuel supplier. Formerly Mallinckrodt Nuclear. Facilities at St. Louis and Hematite, Missouri.
DEVELOPMENT / Oldest commercial independent nuclear R & D organization. Formerly NDA. Facilities at White Plains, Eastview and Pawling, N. Y.; and Stamford, Conn. (Ray Proof Corp., a subsidiary).
FUELS / A major supplier of reactor cores. Formerly Olin nuclear fuels. Facilities at New Haven and Montville, Conn.
UNITED NUCLEAR
CORPORATION
100 East 42nd Street, New York 17, N. Y. YUkon 6-4191
1730 K Street, N.W., Washington 6, D. C. FEderal 3-2376

AEC Operating Staff Streamlined in Shake-Up

In probably the biggest shakeup since AEC's founding in 1947, a major streamlining of the agency's operating staff was announced last month. It is aimed at "improving effectiveness . . . , shortening the chain of command and communications with field operations, strengthening the role of the operations office managers, and relieving headquarters program divisions of administrative and supervisory burdens." (*See chart next page.*)

Biggest change involves removing the operations offices from direct program responsibility for the work of the national laboratories, which are brought into closer relationship with AEC's Germantown headquarters by having them report henceforth to an assistant general manager for research and development—new post. This new assistant GM—first holder of the post will be Spofford G. English, former deputy director of the research division—will be responsible for program direction of all non-weapons research-development except that concerning Project Plowshare (peaceful uses of nuclear explosions). Plowshare is made the responsibility of a new Division of Peaceful Nuclear Explosives under John S. Kelly, reporting to an assistant general manager for plans and production.

Reporting directly to English will be Argonne, Oak Ridge National Laboratories and Los Alamos Scientific Laboratory, the Lawrence Radiation labs at Livermore and Berkeley, and the Ames Laboratory. In an exception to the new pattern, Brookhaven National Laboratory will be administered by a new Brookhaven office (formerly Brookhaven Area Office of the New York Operations Office) which will report directly to English. NYOO will continue to provide administrative support to the new Brookhaven Office, but will not supervise it.

Another far-reaching change in management method ends the system whereby each field operations office was run by the Germantown headquarters most directly concerned. Affected by the change are six multipurpose operations offices: Chicago, Idaho and New York (formerly reporting to Reactor Development division); and Oak Ridge, Savannah River and Hanford (formerly reporting to Production division). Henceforth a conventional "staff and line" management concept will obtain: all headquarters divisions, including those that heretofore had line responsibilities, are now essentially staff organizations and will act for the general manager in carrying out their program functions in relation to the operations offices. These will report directly to the general manager's office.

Exceptions are made for the Military Applications division, which continues to direct the activities of the Albuquerque and San Francisco operations offices; the Brookhaven Office; and three special-purpose offices (formerly operations offices): Schenectady and Pittsburgh Naval Reactors Offices, which continue to report to the Reactor Development division, and the Grand Junction Office which continues to report to the Raw Materials division.

The assistant general managers will be delegated a greater amount of responsibility for management of their assigned areas of operation. Other new assistant general managers, besides English, are George F. Quinn, who will handle plans and production including the new Plowshare division, and duties formerly assigned to the Assistant GM for Manufacturing—a post now discontinued; and Edward J. Bloch, who becomes Assistant GM for Operations with supervision also over divisions of Contracts, Construction, Operational Safety, and Labor Relations.

The new Division of Contracts, headed by John Vinciguerra—formerly head of the Office of Contract Policy—takes over the functions of that office, now discontinued, plus most of the contracting functions of other divisions.

This reorganization does not affect AEC's regulatory staff, which has already been the subject of an organizational streamlining this year (NU, May '61, 27).

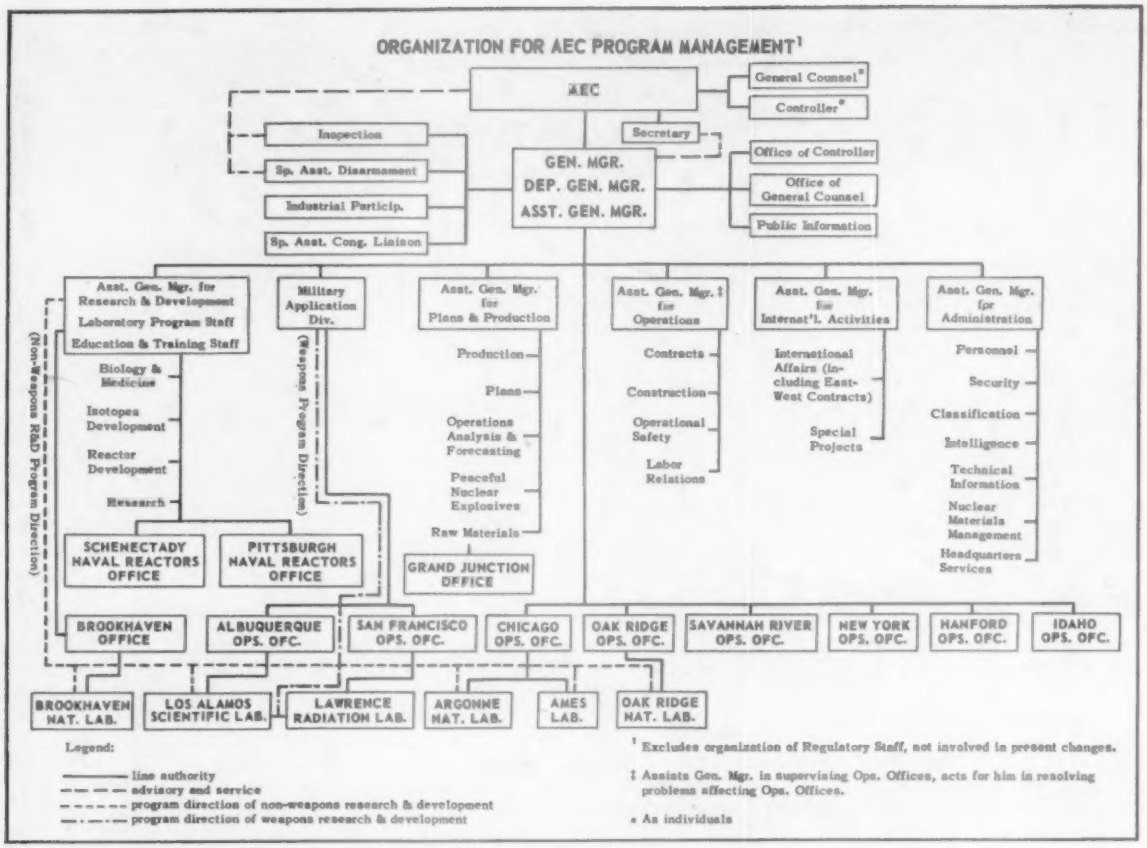
NPR Fight Threatens Entire Power Program

A second vote of the House of Representatives last month against power-production facilities of 700–800 Mwe at the Hanford New Production Reactor has brought the threat of a complete breach between the Federal Government and the private-utility industry on the development of nuclear power. On the basis of a series of interviews with Congressional and Administration leaders—shortly after the House had voted 235–164 to block NPR's generation facilities—the possibility of drastic repercussions on the nuclear-power program as a whole could not be overstated.

Despite defeat by a substantial margin in the House, Democrats of the Joint Committee on Atomic Energy were refusing to concede on NPR. Moreover, they were criticizing those private-utility interests actively opposed to NPR power in the most outspoken terms. In short, there were all of the elements of a showdown: "They [the private utilities] want reactors built only on their terms," a JCAE Democrat charged. "Things may be deadlocked for a few years, but we cannot agree to their terms."

At AEC, where all five Commissioners were supporting NPR's conversion, Chairman Glenn T. Seaborg said that the Commission had halted its study of possible incentives to get more reactors built, because of the NPR controversy. "We are not doing very much, at the moment," he said, "and you can quote me on that." The Commission staff was just completing its proposals to the five-man Commission when NPR reached the showdown stage in early August.

There appeared to be two major possibilities in Congress to break the deadlock: 1. adoption of a "stripped down" version of AEC's construction authorization bill—killing not only the $95-million authorization for NPR generators but also $19-million in research-development and fuel-charge-waiver aid for private-utility reactors and, possibly, the 15–20-Bev Stanford accelerator; or 2. a compromise on the authorization bill which would permit some, if not full, power production by NPR and, at the same time, permit some Congressmen who have voted on the record against NPR power to switch their votes. If no compromise can be reached, the JCAE Democrats can be expected to embark on a program of "massive retaliation" against the private-utility industry, including whatever steps are in their power to sever all forms of aid in the construction of power reactors.



AEC Plans to Issue Revised Site Criteria by Year-end

AEC hopes to have, by year-end, the first reactor site criteria ever drafted to aid potential reactor builders and operators. AEC officials made it clear last month that they intended to complete preparation of guidelines despite the controversy which followed their first publication by AEC (see NU, March '61, 23)—after redrafting the criteria to reflect industry comments.

In the many comments submitted to AEC after their publication in this first-proposed form there was almost no opposition to the promulgation of site criteria. Rather the comments were on their form and wording. AEC's regulatory staff was busy analyzing the comments last month and, over the next few months, expected to: **1.** Complete its analysis of the public comments; **2.** make necessary changes and revisions in the criteria; **3.** submit the finished criteria, their bases and justification, along with a recommendation that the Commission accept them and **4.**—if the Commission agrees—they become the blueprint for locating licensed reactors in particular geographical areas of the country.

The Commission staff says the criteria will not be looked upon as the be-all and end-all of siting problems and situations. They explain the criteria as an important first piece of paper and starting point—with built-in flexibility—to offer guidance to those embarking on reactor construction and operation.

Briefly stated, the proposed criteria mean that large reactors will be built farther and farther away from centers of large populations. They list these factors which will receive long and hard looks at Germantown before potential reactor sites are approved or disapproved:

Population density in the area of the site, and uses made of the area—whether industrial, farming or residential; physical characteristics of the site—seismology, meteorology, hydrology, etc.; technical features of the particular reactor, including power levels and extent to which reactor design incorporates proven engineering standards—or extent to which the design includes unusual features which could contribute to accidents.

AEC-JCAE Compromise to Limit Mandatory Reactor Hearings

AEC last month approved a regulatory compromise with the Joint Committee on Atomic Energy under which amendment of the 1954 Atomic Act will be sought this year to:

1. limit the mandatory-hearing requirement on licensed power and test reactors to a single hearing at the construction permit stage (further hearings at AEC's discretion);

2. give AEC authority to appoint ad hoc boards of three men—two technical, one administrative or legal—to conduct licensing hearings when appropriate (AEC would continue to make licensing decisions);

3. allow the Advisory Committee on Reactor Safeguards to use some discretion on which reactor projects it will review for AEC (ACRS is now required to review virtually every reactor and every important change in a reactor).

The compromise, worked out by the AEC and JCAE staffs would need implementing legislation.

Russia Claims Most A-Subs; UK Building 2, France 1; Italy Plans

Russia last month made the strongest, most explicit claim yet to having nuclear-powered submarines in large numbers. The claim was made through the government newspaper Izvestia and was promptly contradicted by a top U. S. military expert, Sen. Henry M. Jackson (D-Wash.).

Four foreign countries are working on developing nuclear naval vessels—all of them submarines: Britain, France, Italy and Russia. Their progress can be summed up this way: Britain—one sub nearly completed, a second in advanced planning and development; France—development of first sub well under way; Italy—pre-design, planning stage; Russia—complete mystery.

Soviet Union. The Russian claim was made in a retort to a speech by U. S. Attorney General Robert F. Kennedy at the launching July 15 of the ninth Polaris-firing submarine *John Marshall*. Izvestia declared July 21 that the Red Navy had "atomic submarines armed with the mightiest rockets of various types" that operate "not at a lesser but at a greater speed than U. S. submarines and were not fewer in quantity but greater."

Sen. Jackson, chairman of the Joint Committee on Atomic Energy's weapons subcommittee and a member of the Senate Armed Services Committee, at once dismissed the Izvestia article as Berlin-crisis propaganda. Russia does not "even come close" to the U. S. in number, variety and quality of nuclear subs, Jackson said.

A fortnight later—after Russia had staged a naval review in Leningrad harbor at which no nuclear submarines were shown—the Senate Preparedness subcommittee heard testimony behind closed doors from Admirals Hayward (head of naval research and development), Raborn (Polaris project), Galantin (undersea warfare) and Lowrance (naval intelligence). Afterward Sen. Jackson declared, "We are ahead of them on this. If they had even 10 or 12 nuclear-powered submarines able to launch missiles the Soviet would put them on public display for propaganda purposes."

Reports about Russia have mentioned two groups of nuclear submarines, of three each, said to be under construction. The presumed first ship of this group has been reported under construction for at least three years, but has never been reported going to sea or ready to do so. The three reactors that power Russia's nuclear icebreaker *Lenin* have been said to be each about the size of *Nautilus*' reactor, and it has been suggested that Russia might have placed her submarine prototype reactor aboard an icebreaker—instead of on land in a desert as the U. S. did—thereby gaining the advantages both of seagoing experience and of international propaganda credit for a peaceful application of nuclear energy.

HMS Dreadnought, remarkably whalelike

Britain. Furthest advanced of the three Western allies is Britain, whose *Dreadnought* is fast approaching readiness for her first trip to sea on trials. *Dreadnought* contains a U. S.-supplied S5W-2 (*Thresher*-type) reactor that saved Britain an estimated three years (not to mention about $50–75-million in duplicative development costs) in getting a first nuclear submarine into operation. At Dounreay (adjacent to the experimental fast breeder power reactor) is now rising the land-based prototype for the first British-designed and -built marine reactor—also a pressurized water type. Its first seagoing version will propel the Royal Navy's second nuclear sub, HMS *Valiant*, to be laid down soon.

Her keel laid by the Duke of Edinburgh June 12, 1959, and launched by Queen Elizabeth Oct. 21, 1960, *Dreadnought* is being built by Vickers-Armstrong at Barrow-in-Furness. She is by a wide margin Britain's largest submarine at 3,500 tons, 226-ft length, 32-ft beam.

Rolls-Royce Ltd. acted as the Admiralty's agent in purchase of the reactor from Westinghouse. The latter set up a special branch to handle the *Dreadnought* reactor, including procurement of components, training, and aid in installation. Among U. S. manufacturers who became purveyors to Her Majesty's Royal Navy were Babcock & Wilcox, the pressure vessel and two steam generators; Foster Wheeler, pressurizer; Curtiss-Wright, reactor plant controls; Westinghouse Cheswick plant, reactor core. Others included Mallinckrodt Nuclear Corp., supply of uranium metal to Cheswick for the fuel elements (first time uranium for a nuclear warship was supplied by a commercial source); Alco Products, three fresh- to salt-water heat exchangers and two emergency shutdown coolers; Electric Boat div. of General Dynamics, design and technical aid in installing the system.

Over 100 British engineers came to the U. S. for training and liaison—to Westinghouse in Pittsburgh and other companies—for periods from two weeks to two years; some 50 crew members were assigned to U. S. nuclear submarines for training.

France. Sea trials about 1967–68 for the first of a series of three submarines—that's how France's Chief of Naval Operations, Adm. Canabier, sums up his service's nuclear plans.

Going it alone after the U. S. rejected their request for a reactor and/or technical help, the French now expect to have a full-scale land-based prototype of a submarine reactor plant operating in 2½ years at the new Cadarache reactor center. The prototype will be a pressurized-water unit with power output comparable to a U. S. S5W. Fuel for the prototype (but not for any seagoing units) will come from the U. S.; the design will be all-French.

Although, as a high-ranking French Navy officer admitted to NUCLEONICS, the French started off on the wrong track with the *Q-244* and its natural-uranium fueled, heavy-water moderated reactor (which grew too monstrously big for a sub), they are now confident of success. About 75% of the *Q-244* research has proved useful for enriched-U reactor work. *Q-244*'s hull at Cherbourg will now be completed with conventional propulsion and carrying large amounts of experimental radar and sonar gear; the first nuclear sub hull will be started on the same ways after *Q-244* is launched next year. Funds for it are already included in the 1960–64 budget.

In January, 1961, the U. S. delivered 44 lb of 90% enriched U, made into U-Al plates clad in aluminum, for use in a zero-power experimental reactor, Alizé, at Saclay; two weeks after the fuel arrived, Alizé went critical. The French have already ordered fuel for a larger critical assembly, Azure (under the U. S. bilateral, France can get up to 200 lb U-235). Azure will be an intermediate stage between Alizé and the full-scale prototype.

Italy has had a nuclear submarine study project going since end-1958, and has set up a research group, CAMEN, in Leghorn, with a laboratory equipped with a pool-type research reactor. A Defense ministry study group of Navy officers, is now working on the project in Rome.

Project VELA: West Well Into Bomb-Test Detection Program

The United States through Project VELA and, in a smaller way, the United Kingdom ("ORPHEUS") are deep into a three-phase research-development program to perfect an international system for nuclear-weapons test detection—despite the real possibility that the system may never become operational unless the West "goes it alone." Two of Project VELA's three phases involve techniques that depend on radiation-detection instruments for which AEC's Los Alamos Scientific Laboratory has development responsibility.

All phases of the U. S. program—"Uniform:" underground test detection; "Sierra" and "Hotel:" high altitude (above 18–35 miles) detection by surface-based and satellite-borne instruments, respectively—are either already into or about to go into the hardware stage. Work on all phases will continue for about 3–5 years.

The Defense Dept.'s Advanced Research Projects Agency (ARPA) has over-all management responsibility.

Estimates for construction and annual operating costs, respectively, for establishing an international network are: $1-billion to establish, $250-million to operate (less satellites).

The Defense Dept. has allocated an estimated $37-million of its fiscal '62 budget for work on a gamut of VELA projects ranging from basic research to development of advanced systems. Of this, $25-million will be used to continue work on VELA Uniform (*see box next page*), managed by the Air Force Technical Applications Center (AFTAC) and the phase that has the most unsolved technical problems; $10-million will go to further work on Hotel, a phase managed by the Air Force Space Systems Division (AFSSD), Los Angeles; the final $2-million will be applied to the AFTAC-managed Sierra phase.

AEC will contribute $23-million of its funds for VELA as follows: Uniform, $16-million; Hotel, $2-million; Sierra, $1-million; general support, $4-million. Defense is considering adding still another $22-million to this combined Defense/AEC $60-million total allotted for '62.

VELA Sierra Progress

In Sierra, the $3-million total will sustain projects already under way and initiate new studies and additional development work through contracts awarded government agencies, universities and private industry. Research-development work on Sierra, a system designed to operate through a network of 180 ground control posts primarily at 600 to 1,000-mile intervals throughout the world is being concentrated on three detection methods —optical, radio-frequency and geophysical. They will be used to detect visible light and radio signals released directly when a test shot is made, and effects on the atmosphere and the earth's magnetic field caused by blast-generated X-rays and gamma-rays.

Three optical techniques are being developed: 1. a direct optical method to detect visible light in about the first 100 microseconds. Now in the pre-prototype stage, its proposed 200 channels, making use of arrayed telescopes, light filters and photomultipliers, would divide the sky into 200 sections. Four of these channels, reportedly capable of detecting an explosion of several megatons at approximately 1 million miles in daylight, are now being evaluated at LASL. Equipment cost for a Sierra station: $500,000 to $1,000,000.

2. Two prototype devices have been developed to measure fluorescence caused when thermal x-rays from a nuclear blast are absorbed in the upper atmosphere and interact with nitrogen molecules to produce visible light emissions. One is being used for research at Los Alamos; the other is being modified at the Boston lab of Edgerton, Germeshausen & Grier, Inc. Both are equipped with wide-angle lenses, sharp-cutoff interference filters, photomultiplier tubes, amplifiers and analyzers. Each has six photoheads which operate in pairs in coincidence. Two of the pairs scan for fluorescent radiation from the upper atmosphere, the other for lightning. They enable LASL scientists to distinguish between nuclear test-induced fluorescence and lightning effects.

Effective detection range is estimated at 2–5 million miles for a 1-megaton blast during the day, 50 million miles at night. Cost of installing this equipment at a Sierra-type station: ~$100,000.

While LASL scientists have been developing optical techniques, scientists at the Bureau of Standards at Boulder, Colo., the Navy Electronics Laboratory, and industry contractors have been working primarily on three radio frequency pre-prototype techniques: use of the riometer, a sensitive radio receiver designed to measure the intensity of continuous radio signals generated at great distances in space; studies of the detonation-generated electromagnetic pulse; and improved use of backscatter radar. The third method—geophysical—of detection involves studies by the Army Signal Corps Labs of perturbations in the earth's magnetic field, and the electrical currents that likely will occur with a high altitude nuclear detonation.

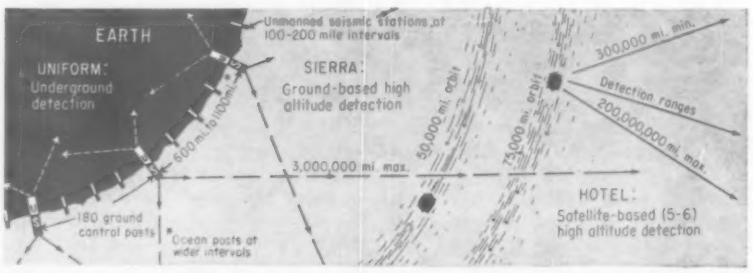
Why a Variety?

There is a twofold reason: first, to devise a system of complementary techniques, especially in attempts to overcome detector range limitations and in efforts to penetrate probable violator shielding (by adding shielding material to the payload); second, to understand better atmospheric phenomena—effects of solar flares, meteorite showers, lightning, the auroral effect, clouds and natural background radiation—so that detectors can effectively discriminate between natural and test-induced radiation.

To solve these problems, Los Alamos scientists, under the direction of Herman Hoerlin and Donald Westervelt, and Sierra contractors working with LASL are trying to increase detector range by using larger photomultiplier tubes.

LASL scientists believe they will be able to penetrate a violator's shield with direct optical devices. Theoretical studies on this problem are expected to continue for another year.

On radiation-discrimination problems AEC-developed devices with discrimination capabilities have been tested—with satisfactory results—in Alaska and Greenland to determine their ability to distinguish auroral phenomena from blast-generated radia-



PROJECT VELA CONCEPT: Detection of nuclear-weapons tests—anywhere

tion. Spectrolab, Inc., and other Sierra contractors are trying to improve the filters used at Los Alamos. Moreover, an experimental cloud study initially has indicated that clouds will not seriously degrade the instrument's discrimination capabilities. Los Alamos officials believe they have resolved the discrimination problem. Most Sierra work at LASL during the past year was concentrated on the fluorescent method. As a result, Lab officials have found "that the fluorescent method has approximately the range expected, the equipment can be built and operated and, we are yet to see natural signals . . . that can be mistaken for nuclear detonations." Work during the coming year, then, will be concentrated on perfecting the direct optical system.

VELA Hotel Advances

No matter how much improvement can be made in Sierra equipment, the inherent limitations, which restrict its detection capabilities to ranges of roughly 100,000 to 5,000,000 miles, make it apparent that the Hotel system must be fully perfected. This is especially necessary because in deep space the atmospheric radiation and other phenomena that would interfere with data gathered by a potential violator are absent. As a result, a potential violator has an ideal area for testing out to ranges of 200-million miles, the maximum distance at which a violator could test practically and economically. (At 200-million miles, it would require about a year before a violator could obtain information.)

The agencies principally involved in Hotel include AEC, primarily responsible for radiation-detection devices, including sensors and logics; NASA, primary vehicle interest, especially in launching and telemetering; and the Defense Dept., responsible for systems integration. The Air Force Space Systems Division is coordinating these agencies' efforts and will select the vehicle contractor—a decision soon to be made. On the working level, LASL is responsible for actual detector development—with Sandia Corp. responsible for developing associated electronic analyzing equipment and for data reduction.

Of the $16-million allotted Hotel for '62, most will be used to cover costs for developing exploratory satellites, high-performance boosters, and sensors and logics.

Major dollar contractors thus far are General Dynamics/Astronautics, awarded a $1,999,000 ARPA contract for development of an environmental test satellite, and Lawrence Radiation Laboratory, a $1,500,000 AEC/ARPA contract for development of a piggyback satellite payload.

Neutrino Detector Could Make 'Uniform' Effective

A new approach to detection of underground nuclear explosions was proposed last month by Richard King, president of Advanced Research Corp. (NU, July '61, 31). King, who believes that the interaction of test-generated neutrinos with other matter can be measured, has suggested to the Air Force Office of Scientific Research that there is a possibility of using the measurements to help develop a neutrino detector—if the energy of their interaction is high enough.

King's theoretical approach to underground detection could be significant in the Uniform phase of Project VELA, which has been based primarily on seismic and electromagnetic detection techniques. But these methods are limited, especially in detection of blasts with yields of less than 20 kilotons whose effect can be shielded by the tester or reduced by natural factors.

However, free neutrinos, apparently acting only through weak interactions, can penetrate virtually all matter, therefore can't be shielded against.

Three Detector Types

Three types of detectors are under development at LASL for satellite space detection. **1. Neutron.** Internally-mounted detector with several boron trifluoride counters or neutron-sensitive scintillation counters to measure background intensity, recognize detonations by neutron counts above the background intensity and telemeter neutron time data back to earth.

2. Gamma-ray. Also internally-mounted, with six scintillation counters arrayed beneath the surface skin to cover all directions in space. Each counter, a solid plastic fluor about 4 in. in diameter by 3 in. long, will be mounted on a photomultiplier tube. The fluor will be shielded from low-energy background radiation perhaps by a one-eighth in. cover of aluminum. The gamma-ray detector will detect a nuclear detonation by identifying the released gamma-rays through their short time duration—30 billionths of a second.

3. X-ray. With thin dome-shaped fluors extending out from the satellite's surface. They will absorb x-rays and convert this energy to visible light which will be measured by standard photomultiplier tubes shielded from sunlight by thin metalized films. Seven sensitivity levels built into the electronics would measure pulse intensity. Ten x-ray detectors will be employed to cover all directions in space.

Ten guard counters, with the x-ray detectors, will discriminate against radiation produced in the detector package by cosmic rays.

Of the three, only the x-ray detector will be effective at distances of more than 300,000 miles from the satellite. Therefore, only the x-ray detector will have the capability of covering more than 99.99% of the total space available to a test-ban violator. The three experimental detectors have been subjected to some testing in "piggyback" rides on rocket probes. LASL scientists, under the direction of R. F. Taschek, are preparing instruments for future flight tests: five launches from the Atlantic Missile Range in the next five years, each sending two spacecraft into circular orbits at altitudes of 50,000–75,000 miles; another satellite equipped to detect electrons trapped in the earth's magnetic field will be placed in elliptical orbit around the sun.

As a result of past tests, LASL scientists found the neutron detector more effective when the single boron-filed proportional counters are used (instead of the scintillation counters) because of their ability to discriminate more effectively against gamma radiation. LASL scientists feel that the x-ray detector is the "biggest problem" because of the lack of knowledge of the effect of solar flares (short time radiation bursts from the sun) on it. However, LASL now has working models of the x-ray detector, a prototype of which will be tested on an Air Force Blue Scout rocket probe this fall.

Detector Life Span

LASL scientists hope the initial life span of the detectors will be 6 months, but ultimately aim for a span of 1 or more years.

Hotel scientists face problems similar to those in the Sierra system. Radiation discrimination is one such problem. It is particularly caused by cosmic ray "showers" in the vehicle itself and solar flares. LASL scientists hope to help solve it by taking spectral measurements of background radiation in space during future exploratory satellite and rocket probes. One method: to determine energy distribution of the particle fluxes by using an electrostatic analyzer working between 1 kv and 1 Mev. In this way something can be learned about the nature of low-energy particles generated by the sun and, as a result, detectors with more effective discriminatory powers can be developed. Detectors "piggybacked" on two NASA Ranger and one Deep Scout probes will soon be sent aloft for this purpose.

According to Air Force Major John Poulson, "the over-all 'false alarm' rate for the system can be adjusted to . . . one per hundred years." Violator shielding is another problem. "The answer . . . depends on LASL's ability to develop an X-ray detector capable of measuring softer radiation in the 100-volt range instead of the kv range," a project official said. In addition to developing operational detectors, Hotel scientists must select a satellite system. Possibilities: Argus, an inexpensive, powerful single satellite orbiting below the Van Allen radiation belts; the far earth system, a six-satellite system orbiting at a range of 50,000–75,000 miles that would provide full coverage except behind the sun or moon and escape significant atmospheric background radiation effects; the near earth system, an expensive, multi-satellite alternative to the far earth system; and solar satellites, a four-satellite system to cover the areas behind the sun and moon.

Far Earth System

"Of the four," a top Hotel scientist said, "we are primarily concerned with . . . the far earth system, because . . . (it) is more economical and has greater capabilities." He believes that, if the system "works," solar satellites won't be needed.

To attain their "operational-in-two-years" goal, project officials need continued instrumentation development. In particular, they would like to see industry develop scintillator type materials that respond to x-rays by producing light in the ultra-violet spectrum, scintillator material that will move the sensitivity of scintillators down so they can register lower x-ray energies and photomultipliers that will be sensitive in regions below the 3,000-angstrom level.

In summing up VELA progress to date, Carleton Beyer, formerly in charge of the program, said he believes "we can achieve an effective control system." "However," he added, "we want to do better, to make it as good as we possibly can."

Beyer was succeeded in July by George F. Bing as assistant ARPA director for nuclear-test detection.

Will it be good enough to cover the world successfully without Soviet cooperation? Most project officials believe Hotel will. Sierra, they believe, will at least be limitedly effective.

Richard Latter, chairman of the Defense Dept. nuclear detonations detection group, testified at the JCAE's July hearings on Project Vela progress that actual atomic tests and experimental satellite launchings are the only way to develop a really effective system.

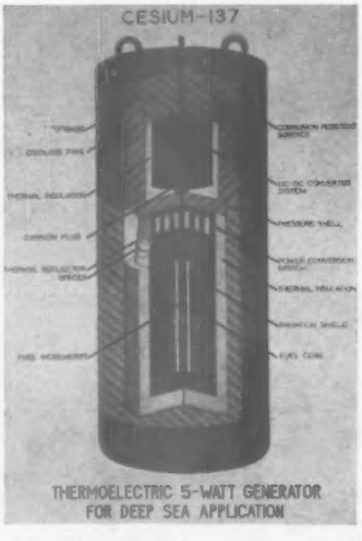
AEC Isotope Unit Sponsoring Major Development Effort in Power Supplies; Lamont to Use Cesium-137 Device

AEC's Office of Isotopes Development, with a minimum of fanfare and an astoundingly low budget, has built up a surprising position in the development of isotopic generators by industry contractors.

The advanced extent of progress under OID sponsorship was underscored last month by three developments: 1. Martin Co. completed delivery of a strontium-90-powered weather station to a site in northern Canada (NU, Aug. '61, 25); 2. Lamont Geological Laboratory disclosed plans to drop into the Atlantic Ocean south of Bermuda—early next year—the first nuclear generator to go into the sea (now under fabrication by Royal Research Corp., Hayward, Calif.); and 3. OID disclosed that Martin Co. is expected to develop, by around year-end, a proof-of-principle device in the milliwatt range of a strontium-90 "battery" in which both beta radiation and heat would be converted to electrical energy.

All three of these projects have been funded by OID, at a total investment in '61 of $350,000. The Office had also been the prime mover in Martin's initial work on the first workable generator fuel—strontium titanate—and is currently considering support of a broad research-development program to increase the availability and lower the costs of fission-product materials of interest in generation applications.

This possible program has been dubbed Project SHARE: Systems for Heat and Radiation Energy. The thinking at this point is to take a hard look at the entire fission-product picture—storage, separation, packaging, use in unseparated form, etc.—with the long-term view of "turning a liability into an asset." Preliminary paper studies are being carried out at various AEC laboratories.



ROYAL GENERATOR measures 30 in. high by 13 in. dia, weighs 500 lb

Lamont Device

Converting what was to have been a "proof-of-principle" device into a working power supply, OID, the Lamont scientists of Columbia Univ. and Royal, a subsidiary of Royal Industries, are collaborating on completion of a seismographic station by the end of this year or early next. The 5-watt generator is to be delivered to Lamont in December. "We hope to be ready [to use it] almost as soon as it gets here," a Lamont official explained.

The cesium device (*see cutaway*) will be cylindrical, 30 in. high by 13 in. dia, and 500 lb in weight; eight inches of its length and fifty pounds of its weight will be accounted for by a solid-state, current-conversion device. The cesium source will be fixed in pellets of borosilicate at Oak Ridge National Laboratory (the compound is called cesium polyglass and contains about 47% cesium). Seven polyglass pellets, 2½ in. dia by 1¼ in. high, will be stacked vertically in a close-fitting cylindrical shield of tungsten. This, in turn, is to be surrounded by two layers of insulation—fiberglas to trap conductive heat and gold-plated metal to trap radiant heat.

A configuration of 54–60 thermocouples of Royal design will convert the heat to electricity, with overall system efficiency of at least 7%. Royal said it was using lead telluride in the thermocouples but that the conversion system was a "new approach" which could not be detailed for proprietary reasons. The entire configuration will be protected by a 2-in.-thick aluminum-alloy shell and submerged to a depth of 2,500–3,000 fathoms (design rating: 6,000).

Strontium "Battery"

OID officials said the low-power generator under development at Martin would use stable strontium-titanate as the conversion material—that is, strontium-90 titanate would be gradiently dispersed in inert strontium-titanate to produce a power system in the milliwatt and low-watt power ranges. Upper temperature capability was uncertain but it is assumed that the system would go considerably higher than the upper temperature limit of lead telluride (900–1,000 deg F), because the titanate's melting point is 3,700 deg F.

Marshall Nuclear Unit to Ask Vehicle Proposals This Fall

Marshall Space Flight Center of the National Aeronautics and Space Administration will invite proposals from the aircraft-missiles industry this fall for development of the upper-stage vehicles which—later in this decade—will be boosted high over the south Atlantic in flight tests of this country's first nuclear rockets. The NASA invitation will be drafted and issued by the first Marshall group to concern itself solely with nuclear rocketry—the new Nuclear Vehicle Projects Office (NVPO), under Air Force Col. W. Scott Fellows (NU Wk, 29 June '61, 2).

Upon selection of a vehicle-development contractor or contracting team, NASA and AEC will have completed the major industrial assignments looking toward first nuclear-rocket flight in 1966–67 (RIFT: Reactor in Flight Test) from Cape Canaveral. Aerojet-General Corp. and Westinghouse Astronuclear Laboratory, the team selected to develop the RIFT engines, formally signed a $6.3-million contract for the first phase of their effort in late July (*see page 32*).

In a significant development in July, Marshall agreed to enlarge the Saturn C-3—a proposed 3-million-pound booster using two F-1 engines—so its shell can be mated with nuclear upper stages developed in the nuclear-rocket program.

NVPO Role

NVPO's current mission is to manage developments of the RIFT vehicles. Longer range, it will supervise and coordinate development at Huntsville of high-thrust nuclear-propulsion rocket stages for Saturn and subsequent vehicle systems, for which Marshall will also have flight-test responsibility.

Fellows' ten-man office will be "the focal point for all Marshall effort in the RIFT program" (nine of Marshall's ten research-development divisions will be participating). "We plan to use the strong Marshall capability for in-house research-development work to the very maximum," Fellows explained, "and go to contractors for such additional work as might be required."

RIFT contracts with industry, he said, will be handled either directly by his office or will be assigned by NVPO to the appropriate Marshall division for contractor selection. The tendency will be for NVPO to select contractors for research of a "broad" nature—that is, areas in which two or more divisions would be interested such as materials and radiation shielding and damage.

Divisional Responsibility

The three Marshall divisions most deeply concerned with RIFT at this point are:

Structures and Mechanics, headed by Wm. A. Mrazek, to which NVPO is attached (the chain of communications on RIFT matters is this: Fellows to Mrazek to Wernher von Braun, Marshall director—then to NASA headquarters and to Harold B. Finger, chief of the AEC-NASA Space Nuclear Propulsion Office and assistant director for nuclear applications in NASA's Office of Launch Vehicle Programs).

Research Projects, headed by Ernst Stuhlinger, world authority on electrical propulsion. The division is supporting the RIFT program in the areas of nuclear physics and radiation shielding, effects, hazards, etc. Its principal concern, however, is electrical propulsion.

Launch Operations, directed by Kurt H. Debus. Debus' division is responsible for planning and executing checkout and launching of all NASA booster and space vehicles, including those with nuclear stages.

Fellows, 42, previously assistant manager for technical programs at the Lockland Aircraft Reactors Operations Office at Cincinnati, has been assigned to AEC nine of his twenty years in the Air Force, most of these at Lockland. He spent a year at the Oak Ridge School of Reactor Technology and is a former chief of the Guided Missile div. of the Air Research and Development Command.

"We have jumped in here with both feet," he said in an interview. "The eight engineers we have hired are quite knowledgeable in the field and quite well-known. We will have a really hard core of key people who know their business. We are covering quite a few areas: structures, nuclear analysis, testing, vehicle integration, guidance and control, etc."

He foresees no immediate expansion of his technical staff, noting that the present unit "should be able to handle all our problems for the next year, certainly during the study phase."

His deputy is William A. Brooksbank, 38, who has been at Huntsville since 1958, and is a former senior research chemist at Oak Ridge.

Electrical Propulsion

In Stuhlinger's Research Projects Div.—employing a total of only about 40 men and women—R. D. Shelton, head of the Nuclear and Ion Physics branch, and about five others are working directly with Fellows' NVPO. Some twenty other technical personnel in the division are engaged on a part-time basis in such nuclear-related fields as electrical-propulsion systems and research on power supplies for electrical propulsion.

Marshall is responsible for development of electrical-propulsion systems and their flight-testing "up to the point of operational status." NASA's Lewis Research Center, Cleveland, also is responsible for extensive research and some development in this field (NU, Aug. '61, 32).

Stuhlinger, strongly intimating he believes the Soviet Union leads the world in the development of electrical-propulsion systems, said he has seen indications that Russian scientists are working at top speed. A leading Russian rocket scientist, he observed, told him at a recent international conference that the U.S.S.R. is "interested in" electrical propulsion. "When he simply indicates they have an 'interest' in this field, I am sure that means they are working on it with great activity and high pressure."

NUCLEAR-ROCKET VEHICLE AND ENGINE personalities at Marshall Space Flight Center (l. to r.): W. S. Fellows, director of Marshall's Nuclear Vehicle Projects Office; H. B. Finger, nuclear-rocket manager; W. von Braun, Marshall chief

REACTOR NEWS

AEC REVAMPS REACTOR DIVISION

AEC has carried out a long-awaited reorganization of its Reactor Development div. Les Staebler becomes associate director for nuclear power applications, in their broadest sense; he will be in charge of all AEC development programs using heat from nuclear reactions, including propulsion. Allen Vander Weyden remains as Pittman's deputy. Nelson Sievering becomes associate director for advanced reactor systems, succeeding Col. Jack Armstrong (NU, Aug. '61, 30); it includes direction of the Pluto (ramjet) and SNAP programs. A third associate director, for operations, is Hugo N. Eskildson. The three associate directors report to Pittman. Four new assistant directors are created: under Sievering will be Col. William A. Tesch, in charge of experimental concepts and compact-power systems, and Edward E. Sinclair, nuclear technology; under Eskildson will be Angelo Giambusso, reactor construction (a trouble-shooting job to keep civilian-reactor construction projects on schedule), and Frank J. Arrotta, administration. J. A. Lieberman becomes assistant director for nuclear safety; Charles Manly and Carson Dalzell are special assistants to Pittman.

MARTIN WINS BARGE-MOUNT REACTOR

The eagerly sought contract for design of a 10-Mwe pressurized-water reactor to be mounted on a Liberty-ship hull went to the Martin Co. Seven other firms had also bid for the 15-month, $644,046 contract with the Army Corps of Engineers, as it is expected to provide the inside track for the subsequent phases of the $16-million MH-1A barge-mount reactor program: construction and test-operation. Martin's partner: Maryland Shipbuilding.

FERMI COMPLETION DATE OFF TO DEC. 15

AEC has granted a Power Reactor Development Corp. request to extend the latest completion date specified in the construction permit for the Fermi fast breeder from July 15 to Dec. 15, 1961. Earlier PRDC had reported to AEC that major work still remaining to be completed included installation of antimissile protection for the rotating shield plug, as an "extra margin of safety against missile action of the plug"; installation of remaining safety and control rods; and installation of special startup instrumentation. Also, nonnuclear testing was still under way, and PRDC estimated the earliest date on which it can be completed is Sept. 30; thus construction of the reactor could not be finished until "some date in October." PRDC hopes to complete regulatory proceedings necessary for the provisional operating license in November, and will continue testing till then.

RICKOVER BETTER AFTER HEART ATTACK

Adm. H. G. Rickover was reported in excellent condition and improving daily in Bethesda Naval Hospital after having suffered a "mild" heart attack July 25.

10 POWER REACTORS MAY START BY YEAR-END

Ten U. S. power reactors, totaling 488 Mwe installed, are ready to go critical in the next 4 months—biggest concentration ever. Most have completed or nearly completed construction and are carrying out final details of installation, and checking out systems and plant. Most still have one or more steps in the licensing procedure to satisfy. The ten include five commercial-scale plants: Indian Point, 255 Mwe; Fermi, 100 Mwe; Hallam, 75 Mwe; Elk River, 22 Mwe; Piqua, 11.4 Mwe; three experimental power plants: Experimental Breeder Reactor No. 2, 16.5 Mwe; Borax V, 2 Mwe; Saxton, 3.25 Mwe; and two military field plants, SM-1A at Ft. Greely, Alaska, 1.7 Mwe; and PM-1 at Sundance, Wyo., 1 Mwe. In addition the Heavy Water Components Test Reactor, a power experiment that will make no electricity, also plans a December startup. Fermi still faces a big legal question mark: whether the unions will intervene again against the operating license; they say they have not yet decided.

10 POLARIS SUBS ACCELERATED

In an unusual acceleration move, the Navy assigned ten Polaris submarines to shipyards for construction before Congress had passed the military appropriation bill providing funds for them—anticipating its passage. Four hulls were let to Newport News Shipbuilding & Dry Dock Co. (for $154,200,000); three to Electric Boat division, General Dynamics (for $128,812,045); two to Mare Island Naval Shipyard and one to Portsmouth (N. H.) Naval Shipyard. Two weeks later the Senate passed the appropriation bill, already passed by the House. In addition to the ten Polaris-firing submarines, the bill also provides funds for three nuclear attack subs, a second nuclear frigate, and a third (conventionally powered) submarine tender for Polaris subs. Meanwhile, the fourth and fifth Polaris subs, *Abraham Lincoln* and *Theodore Roosevelt*, left for the European Polaris base at Holy Loch, Scotland, completing deployment of the first group of Polaris-firing craft; and *Ethan Allen*, first of the second generation, was commissioned at Electric Boat's Groton, Conn., yard on Aug. 8.

THREE BIG COMPONENT JOBS ON NPR

While the political battle ebbs and flows about conversion of the Hanford New Production Reactor to make 750 Mwe in addition to plutonium, components in heroic quantities are being ordered for the big reactor. **Chandler Evans Corp.** got a $993,000 contract for 1,050 process-tube flow-control valves together with an air-supply system and a remote-control panel. The outlet-diversion valves will permit remote individual control of each coolant channel. Delivery is to be completed by April 1962 . . . **Avien, Inc.**, delivered a prototype of a coolant-monitor system to monitor water flow in the 1,050 channels . . . A new firm, **Smith Dynamics**, got its first big job, a $100,000 subcontract from Kaiser Engineers (prime contractor on NPR) for control-rod assemblies.

B&W GETS 2D SPECTRAL-SHIFT CONTRACT

A second AEC contract for $211,000 on the spectral-shift reactor concept went to its originator, Babcock & Wilcox, last month. The assignment is supplementary to the basic $1,223,500 contract awarded last year for study of the proposed light–heavy-water-moderated reactor. The new contract calls for an economic analysis of the system, to be carried out by B&W jointly with Stone & Webster . . . B&W also got a $415,000 contract to design and make a **second reactor-vessel head** for NS *Savannah*, to accommodate control equipment of advanced, simplified design now under development by Marvel-Schebler division, Borg-Warner Corp., for future use in the pioneer nuclear merchant ship.

AEC EXAMINER APPROVES VSR

General Electric's Vallecitos Superheat Reactor was approved for construction by AEC Hearing Examiner Samuel W. Jensch. The 12.5-Mwth experimental reactor is being built for the New York State utility group ESADA. GE selected Bechtel Corp. to be constructor for VSR.

WORLD NEWS

Germany Plans Multipurpose Reactor

A 50-Mwe power-, research- and testing-reactor has been ordered from Siemens by the Atomics Ministry in Bonn, for construction at the Karlsruhe nuclear research center. The 200-Mwth reactor, to cost $25-million, will be natural-uranium fueled and heavy-water moderated. It will be used to test performance of fuel elements for water reactors; for materials testing, and for production of isotopes. In addition, a $7.5-million power conversion plant will harness the reactor heat for electricity production; its cost will be borne jointly by the state of Baden-Württemberg and local public utilities (the members, probably, of the KBWP group). Construction is to start before year's end, for completion late in 1964. Called MZFR (Mehrzweck Forschungs Reaktor = Multipurpose Research Reactor), the unit is hailed as the biggest reactor project on which an order has been placed so far in West Germany, and as a completely new type of reactor, all-German in conception. Siemens says it will mark a decisive step in German nuclear development because it will finally put Germany in position to develop cheap nuclear fuel. It will be the world's only reactor, Siemens also claims, in which reactor materials can be tested not only at high neutron flux but simultaneously at high temperatures: 10^{14} flux, 480–540°F and 1420 psig. It will also make 300 tons/hr steam at 464°F, 467 psig, for the 50-Mwe power take-off.

SENN: Zircaloy Chosen, Contracts Signed

Italy's SENN utility group has signed separate contracts with Euratom and with the U. S. AEC, making its 150-Mwe boiling-water reactor on the Garigliano River the first officially to come under the joint U. S.-Euratom power program. Under the SENN-Euratom contract, Euratom agrees to make available to SENN the enriched-uranium supply for the reactor, and provides for plutonium buyback, chemical reprocessing, and capital loan arrangements as set out in the U. S.-Euratom agreement. SENN in turn commits itself to build and operate the $70-million reactor and to furnish information about it to AEC and Euratom. The contract with AEC establishes SENN's qualifications for ten-year fuel guarantees on maximum fabrication price and minimum core life, if SENN meets certain detailed requirements. Meanwhile it was learned SENN had decided on zircaloy-2 cladding for the fuel elements, ending a long period of uncertainty during which General Electric, the reactor's designer-builder, was proposing that stainless steel cladding be substituted for the originally-planned zircaloy-2. In Brussels it was said SENN's subsidy from the Euratom research fund may reach $7-million (NU, Aug. '61, 29), helping defray the cost of the zirconium. Fabrication of the first core is expected to be started this fall. The main buildings on the site are almost completed; criticality is scheduled for early 1963, with full commercial operation to follow that summer.

British, French Plan Tarapore Bid

One French and two British groups were planning last month to bid on India's Tarapore plant, a nuclear station of two 150-Mwe net Calder-type stations. Bids were to be opened Aug. 31. In Britain, General Electric Co. and the English Electric–Babcock & Wilcox Ltd. combine, and in France a group headed by Alsthom (and including Indatom, the GAAA combine of Société Alsacienne de Constructions Mécaniques and Chantiers de l'Atlantique, and Société des Forges et Ateliers du Creusot) were preparing bids. According to advices from Tokyo, New Delhi and Bonn, GEC was to bid as part of an international syndicate with GEC as prime contractor and Japan's Dai Ichi group and Germany's MAN machinery firm contributing in their fields; but in London a GEC spokesman said GEC would "bid on the same basis as for Tokai Mura—that is, as GEC," and did not know yet whom it would use as subcontractors. GEC does have agreements with both MAN and the Dai Ichi, or First Atomic Power Industrial Group (FAPIG), combine. The Japanese group (Fuji Electric, Kawasaki Dockyard, Kobe Steel Works, Furukawa Electric, Nissho Trading, and the Dai Ichi Bank) hoped to supply components valued at $28-million, and has asked the Japanese government to finance the cost out of the $80-million credit to be granted to India. Financing was proving a problem for other bidders: India is asking very long-term financing arrangements (at first, 20 years; more recently, 50 years) for the plant, total cost of which was set at from $90- to $120-million. In Germany it was said even the 20-year financing (let alone 50) was impossible, as also the 4½% interest rate desired by India.

Study Big Canadian Reactor for India

Canada and India will make a joint cost study on economic implications of duplicating the 200-Mwe Douglas Point reactor in India. The Indian version would be as nearly identical as possible to the natural-uranium-fueled, heavy-water-moderated and -cooled reactor now under construction near Kincardine, Ont., but "some minor modifications" would take account of different climactic and geographical conditions. India's Atomic Energy Dept. has been authorized to select a suitable site for such a power station in the Delhi-East Punjab-Rajasthan area. The study, to last six months, will determine over-all cost of building the Canadian-type power station in India, together with details on cost of parts that could be supplied by Indian manufacturers and those that would have to be imported. The Indian government will then decide whether or not to build the plant. This would be India's second power station, after Tarapore (*see above*). The Canadian-Indian joint project would be the second of its kind, following the Canada-India Reactor completed last year—a modified copy of Canada's NRX testing reactor at Chalk River, Ont.

New Swiss Nuclear Firm Founded

A National Company for Development of Industrial Nuclear Technology—NGA for short from its German initials—has been founded in Switzerland on the initiative of the Swiss Federal Council. A stock company, it includes all existing companies with an interest in reactor development, construction and operation. Founders are ENUSA of Lausanne, and Suisatom and Therm-Atom, both of Zurich. First project will be construction of a 330-Mwth experimental power reactor—the original Therm-Atom project for a $14-million gas-cooled, pressurized-heavy-water-moderated reactor. Foundation of NGA is the result of protracted negotiations started by the Swiss Federal Council aimed at uniting a number of power-reactor projects that had been started; purpose is to avoid duplication of effort and to help Swiss industry develop new reactor designs.

Petten to Euratom

Holland's 20-Mwth materials-testing reactor at Petten, near completion by Allis-Chalmers, was turned over to Euratom last month, establishing Euratom's fourth common research center (with Ispra, Mol, Karlsruhe).

NEWS IN BRIEF

U. S., Russia Open Talks on Further Exchanges

The State Dept. began negotiations with the Soviet Union in late July for a two-year extension of the current U. S.–Russian scientific-cultural exchange program. It includes exchanges in the nuclear field which have been in progress since 1959 (NU, Nov. '59, 24). Thus far the nuclear program has been moderately successful—its success limited by intervening international tensions. Prospects for future success are as definite as the fluctuations in Soviet policy.

An AEC official said that scope and depth of exchanges had not worked out as well as originally intended. AEC's agreement with its Soviet counterpart calls for exchanges in four areas—personnel, information, joint ventures and instruments. Here's how the exchanges have progressed:

1. Personnel exchanges. Four exchanges of scientists (two U. S. and two Soviet groups interested in high energy physics and fusion in 1960). Director Melvin Abrams of the AEC's East–West Program staff said the U. S. has benefitted from these exchanges, and wants to continue them: "We saw facilities we were never allowed to see before." A proposed power-reactor-exchange visit has been shelved, however, because agreement cannot be reached on the facilities to be seen, and no other personnel exchanges are scheduled.

2. Information.—Approximately 100 papers were exchanged with Soviet scientists on a reciprocal basis during the '60 personnel exchanges. In addition, 138 papers of still undetermined value on high-energy physics, plasma physics, health physics, reactor physics, fusion and other areas of interest were received from the Soviets in late April. AEC has offered to send papers of interest to the Soviets in return. No reply has been received.

3. Joint ventures.—Projects to construct a large accelerator, to confer on waste disposal problems, to develop joint nuclear standards, to compile and evaluate nuclear data jointly and to work closely on the fusion process have been proposed. Both sides are still studying the accelerator construction proposal, with discussions on project feasibility tentatively scheduled for the Brookhaven accelerator conference in September. The waste-disposal conference is still in the correspondence stage. Little has been accomplished in the other project areas.

4. Instruments. (Defined generally as "new scientific instruments.") Nothing has been done to date and nothing is expected.

If the exchange agreement is extended, it will probably result in longer visits (now two weeks) and actual work by exchange scientists. It also may clarify agreement on details of the information exchange. "We expect to sit down and tell them what we want, and hear what they want," Abrams said. "They have been cooperative in the past," he added.

AEC officials feel there are enough proposed joint ventures now. They expect that an extension will provide the opportunity to begin work on these projects.

AEC Near Selection of Gas-Centrifuge Contractor

The AEC expects to pick its first private contractor this month for development work on an advanced gas-centrifuge system for enrichment of uranium (NU, Sept. '60, 17). The contractor's work will constitute one part of AEC's current four-part gas-centrifuge program, and will be performed at the contractor's own facilities. Other parts of the program, which has been budgeted at about $2-million for this fiscal year: continuing basic research at the University of Virginia; continuation of current development work at Oak Ridge's gaseous diffusion plant based on known techniques; and theoretical mathematical studies to be carried out under contract to AEC by a group of scientists from various universities headed by Lars Onsager, professor of theoretical chemistry at Yale.

Fiscal '62 is the first year of a three-year program, at an annual level of $2-million, to solve some of the major technical problems in gas-centrifuge enrichment, including development of high-speed bearings and multicentrifuge cascading. The budget covers both hardware and research-development expenses.

Private Centrifuge Firm. Electronucleonics Corp., a new Caldwell, N. J., firm developing equipment for separation of U^{235} and other heavy isotopes, has filed registration with the Securities and Exchange Commission covering public sale of stock to net $238,000 in new funds. Proceeds from the sale will be used for: building and equipping a new laboratory—$112,500; research-development of single gas-centrifuge units and a gas-centrifuge pilot plant—$62,000; and working capital—$62,000.

Electronucleonics is engaged in developing a reliable, long-term process with a centrifuging unit satisfactory for mass production. (Estimated development time: one or more units—90 days; a small pilot plant—6 months; and a 15-unit pilot plant—1 year.) The company is also developing methods for introducing and removing materials processed in a full-scale plant as well as auxiliary equipment, services and instrumentation. It is seeking research-development contracts from industry and government groups.

Two States Move Toward Regulatory Transfer

Two states moved forward last month to assume eventually certain regulatory controls over radioactive materials as provided by a September, 1959, amendment to the Atomic Energy Act. Kentucky became the first state to complete submission of a proposal under terms of the '59 amendment when state's Attorney General John Breckinridge proposed assumption by Kentucky of part of AEC's regulatory authority over byproduct, source and certain quantities of special nuclear materials. A second state, California, has enacted a radiation-control law giving the state Department of Public Health broad authority to set up rules and regulations for handling radioactive materials. It provides for Public Health Department inspection of both private and public properties to determine the degree of compliance with handling regulations. The department now can also require persons using radioactive materials to keep records regarding their use. The bill authorizes Gov. Brown to enter into an agreement for transfer of radioactive material regulatory authority from the federal to the state government.

Public Aspects To Highlight '62 Nuclear Congress

Sponsors of the 1962 Nuclear Congress and Atomic Exposition said late last month that they will cover nine major interest areas during technical sessions at their June 4–6 meetings in the New York Coliseum. These are: public aspects of nuclear use, problems of advanced reactors, nuclear education for engineers, computational problems in the nuclear industry, application of atomic physics for tests of materials, instrumentation, testing methods, radiochemical separation, and fuel cycling and nuclear safety. In addition, June 4 will be set aside for an all-day general session to discuss operating experience with power reactors. The last Nuclear Congress was held in April, 1960.

RADIATION NEWS

U. K. Medical Supplier Orders 4-Mev Van de Graaff

The first radiation machine to be used for production sterilization of medical supplies in the U. K. has been ordered from High Voltage Engineering Corp. by Smith & Nephew, Ltd., one of Britain's largest surgical-dressing manufacturers. The order was placed through HVEC's independent U. K. affiliate, High Voltage Service Co., Ltd. The 4-Mev, 4-kw Van de Graaff is expected to go onstream within a year, with a capacity of 600 lb/hr of such sterile products as lint and gauze, plasters, ward dressings and bandages. The plant is of commercial size but will operate initially as a pilot plant. Cost of machine and conveyor installed is $280,000.

Smith & Nephew, which had been making extensive use of cobalt-60 facilities of the U. K. Atomic Energy Authority for research-development, said it selected machine radiation over a large cobalt source for these reasons: the machine's high power would permit single-pass sterilization and a simpler conveyor system; a plant similar to UKAEA's Wantage facility (NU, Feb. '61, 100) would not permit sufficient package-shape and -size flexibility; machine beam could be adjusted instantly to various levels from 4 Mev down to 1.5 Mev; and the radiation can be cut off with a single switch.

Activation Analysis Program Scheduled by AEC

AEC's Office of Isotopes Development, in cooperation with the Activation Analysis Research Laboratory of Texas A&M and the International Atomic Energy Agency, has scheduled a two-phase program on activation analysis for the first two weeks of December. Location is the Texas A&M campus, College Station, Tex. The schedule calls for an intensive, 10-day course, followed by a two-day international conference:

Dec. 4–14. Training course, "Modern Techniques in Activation Analysis," oriented toward a broad range of disciplines (review of fundamentals, sample preparation, sources, radiochemistry, applications, future developments). Lectures and laboratory work. Tuition: $250, including registration for following conference.

Dec. 15–16. 1961 International Conference on Modern Trends in Activation Analysis, including sessions on: techniques, radiochemistry, separation and gamma-ray spectroscopy, analytical-data processing, and applications. Last international conference on the subject was held in Vienna in June, 1959. Contact for both events is Richard E. Wainerdi at the Research Laboratory.

Navy Awards Contract on Mixed Fission Products

The Navy's Bureau of Ships has given Bartlett Laboratories, Indianapolis, a contract for development of an isotopic-powered generator using mixed-fission products and based on conversion of the radiation, rather than heat, to electricity. In its first nuclear project, Bartlett is attempting—at this phase of the program—to develop new, efficient materials for converting alpha and/or beta radiation to light, then to electricity. The company indicated it was using gases or fluids, rather than solids, as energy-conversion mediums. "We are hoping to get something much more efficient [than similar systems explored to date] by using different materials," a Bartlett official said. He said the company was well aware that "we are working in an area where there isn't any basic knowledge of materials" but, nevertheless, felt that efficiencies of 25% might be possible via its approach. Under a Phase 1 contract from the Bureau of Ships' Advanced Concepts div., Bartlett has been conducting basic analyses of converter materials. Assuming promising results at subsequent stages, the firm would deliver a 1-watt prototype generator to the Navy in about a year. The generator, if developed, would be used for undersea applications (anti-submarine warfare, etc.).

RDI Accelerates 7 Milliamps of Positive Ions

In a breakthrough in particle-accelerator technology, Radiation Dynamics, Inc., last month said it had produced a 7-milliampere beam of positive ions in a 1-Mev machine ordered by the National Aeronautics and Space Administration. Design goal for the machine (to produce both positive ions and electrons) is 10 ma at 1-Mev, or 10 kw of power and 40 times that available from a comparable Van de Graaff, according to RDI. The 7-ma beam was reached "under steady state conditions," although there is no operating experience as yet.

Army Food Program Hit by Budget Headache

The Army Quartermaster Corps's radiosterilization program for the preservation of food ran into trouble from an unexpected quarter in July when the Defense dept. (DOD) suddenly issued a directive withholding funds. By early August, QMC had been given "temporary relief" to permit it to proceed with the program pending a Defense review of the Army's logistics-type programs. But it was apparent that some doubt would linger until all food-program funds were released. The directive came while the program appeared to be moving more smoothly and efficiently than ever. Without fanfare, final data was being reviewed on the irradiation of bacon —prior to probable submission to the Food and Drug Administration for clearance as the first irradiated food for human consumption. Moreover, the QM's first major research facility at Natick, Mass., was two weeks ahead of construction schedule (due for completion in a year) and the Operations Research Office at Johns Hopkins Univ. had just urged an acceleration of the program.

AEC officials, in the first reaction to the DOD directive, had feared that the adverse move on the Army's program might also adversely affect AEC's low-dose radiopasteurization program. However, both AEC and QM officials were predicting in late July and early August that the "crisis" would be smoothed out without harm to either program. Meanwhile, AEC completed negotiation of a contract with the Univ. of Washington for low-dose research on irradiation of crabmeat and flounder. Under the contract, the school will get a 25,000-curie cobalt-60 irradiator and become the third university to act as a research center under the AEC's civilian program; the others are Massachusetts Institute of Technology (haddock, clams) and the Univ. of California at Davis (fruit).

BDSA Suggests Continuation of Radiation Survey

The Commerce dept.'s Business and Defense Services Administration said last month that it has urged its parent department and AEC to continue the comprehensive survey of the radiation-instrument industry, which BDSA sponsored on a first-time basis for the year 1959 (NU, July '61, 30). The industry's response to the 1959 survey, BDSA said, had prompted the suggestion that the Census Bureau, another agency of the Commerce dept., expand its annual atomic-products survey to include the comprehensive radiation-instrument questionnaire. Census Bureau officials had a negative reaction to this approach, although it appeared that there was still time to expand the atomic-products survey to cover 1960 shipments if the Commerce dept. acts favorably on the BDSA suggestion.

SPACE NUCLEONICS

AEC, AF Conduct First of Five SNAP Safety Tests

On the last day of July, the Air Force sent an advanced Atlas missile down the Atlantic range carrying the first test capsule in a series of tests designed to confirm theoretical data on burnup of radioactive materials in outer space. The test was the first of five to be completed this year (NU, Feb. '61, 28), with the primary concetration on radioisotope-generator cores of the type now orbiting earth in Transit IV–A. First test package carried three simulated cores—two potassium, one sodium—for electronic and visual determination of core burnup and particle dispersion. Participating in preparation of the package was Martin Co. (design and fabrication of cores and capsule), AF Special Weapons Center, Kirtland AF Base, N. M. (package, ejection equipment and telemetry instrumentation) and the AF Ballistic Systems div., Calif. (package and vehicle integration and launch).

The last stages of the series may involve reactor systems for space applications, as well as radioisotopes, but the major test program for reactor systems—including orbital tests—has not yet begun (Project Snapshot).

Aerojet, Westinghouse Sign Nerva Contracts

AEC and NASA signed a six-month, $6.3-million contract in late July with Aerojet-General Corp. covering Phase 1 of engine development for the nuclear rocket (Nerva: Nuclear Engine for Rocket Vehicle Application); just before the announcement, Aerojet had signed a subcontract with the nuclear subcontractor, Westinghouse Astronuclear Laboratory for work involving about $1.5-million of the total. Between the two firms, NASA officials said, about 1,000 people would go to work on engine design, component development, and support for Los Alamos on the Kiwi-B series (liquid hydrogen). Phase 1 was to be completed early in 1962 and the industry contractors were expected to move into a major engine-development effort by early spring.

Nevada Site Activity Brings Las Vegas Expansion

Increasing nuclear-propulsion activity at AEC's Nevada Test Site (National Nuclear Rocket Development Center and site of the nuclear-ramjet reactor tests) has prompted AEC's Albuquerque Operations Office to create an Office of Field Operations at Las Vegas, Nev. The present Las Vegas office will be deactivated and integrated into the new office. K. F. Hertford of the Albuquerque Office did not designate the new office's manager.

Goodrich-High Voltage Reports $658,000 Backlog

A record $658,000 backlog in development contracts has been reported, as of June 30, by Goodrich-High Voltage Astronautics, jointly owned subsidiary of B. F. Goodrich Co. and High Voltage Engineering Corp. Company officials said the firm had been emphasizing long-range development but had recently decided to pursue some shorter-range work like hardware development for ion-propulsion engines. Its major effort continues to be in two areas, however—duo-plasmatron, high-current-density ion engines and electrostatic power-conversion generators for supplying high-voltage electric power to space engines. Major contracts include: ion propulsion, Air Force, $200,000 originally, expanded to $450,000; and power sources for radiation weapons, Air Force, $257,000. It also has a $26,000 contract from NASA's Marshall Center for cathode development (ion engine).

International Symposium on Aerospace Nuclear Propulsion

A four-day meeting on advances in aerospace nuclear propulsion and power sources—the most ambitious meeting ever sponsored by the Professional Group on Nuclear Science of the Institute of Radio Engineers (51 papers)—will be held at Las Vegas, Nev., Oct. 24–27. Co-sponsors are AEC and NASA. First day's program is a series of papers on major aerospace projects and on such broad questions as safety. Most of the presentations during the next two days will cover recent advances in nuclear-space areas which have been given little attention up to now: engine dynamics, controls, instruments and radiation effects on controls and instruments. The meeting winds up on Friday, Oct. 27, with tours of the National Nuclear Rocket Development Center and the ramjet test area.

Major banquet speaker, at a luncheon Oct. 24, will be AEC Chairman Glenn T. Seaborg. General chairman of the conference is R. E. Finnigan of Lawrence Radiation Laboratory, Livermore. About 40 firms have taken exhibit space. Program for the meeting, including session chairmen:

Tuesday, October 24

9:30 General Review of Nuclear Aerospace Programs, A. B. Van Rennes, Bendix. Four Papers:
Nuclear Rocket Engine Flight Operation, Lt. Col. H. R. Schmidt, AEC
ROVER (rocket reactor), R. E. Schrieber, Los Alamos
PLUTO (nuclear ramjet), T. C. Merkle, Livermore
Advanced Propulsion Concepts, T. B. Taylor, General Atomic

12:30 Luncheon Banquet, Glenn T. Seaborg, AEC chairman, "Nuclear Power in Space"

3:00 General Review of Nuclear Aerospace Programs (cont'd), L. Costrell, National Bureau of Standards. Four Papers:
Nuclear Auxiliary Power (SNAP), R. Balent, Atomics Intl.
SNAP Radioisotope Systems, J. G. Morse, Martin
Aerospace Nuclear Power Radiation Safety, J. A. Lieberman and Lt. Col. J. Connor, AEC
The Space Environment, J. E. Naugle, NASA

Wednesday, October 25

9:30 Engine Characteristics and Dynamics, H. Schmidt, AEC
9:30 Nuclear Instrumentation, R. F. Shea, General Electric
9:30 Engine Simulation and Control, E. P. Gyftopoulos, MIT
2:30 Engine Characteristics and Dynamics, H. L. Reynolds, Livermore
2:30 Non-nuclear Instrumentation, A. Gruber, E. H. Plesset Associates

Thursday, October 26

9:30 Engine Simulation and Control, J. E. Perry, LASL
9:30 Effects of Nuclear Radiation on Controls and Instruments, J. B. Trice, GE Space Science Labs
2:30 Selected Topics in Nuclear Propulsion, H. E. De Bolt, AVCO
2:30 Effects of Nuclear Radiation on Controls and Instruments, H. L. Reynolds, Livermore

Friday, October 27

7:00 Tour AEC Nevada Test Site

RCL

TRANSISTORIZED ANALYZERS

fit every budget, meet every requirement...

ECONOMY

MODEL 20620 provides economical instrumentation for budget conscious laboratories and laboratories requiring an additional 128/256 channel analyzer for less sophisticated work.

Less than ***$5000.00***

For complete details request Bulletin A-3.

RELIABILITY

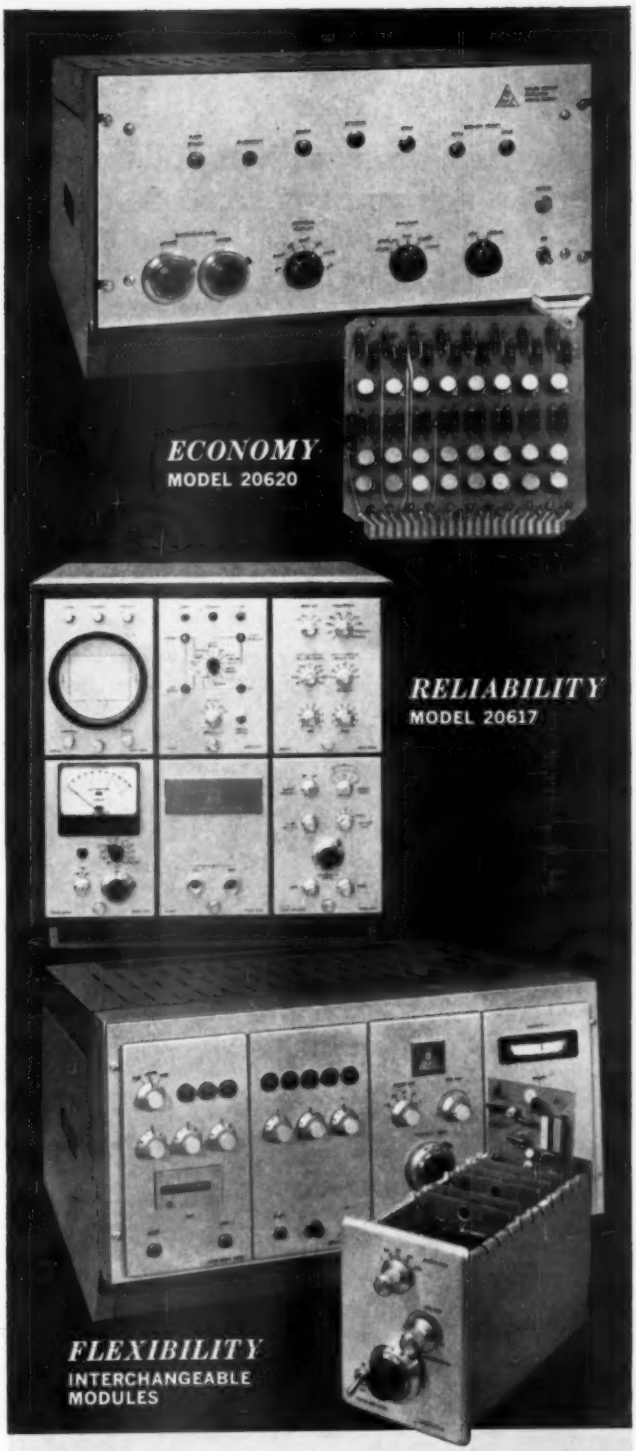
MODEL 20617 sorts by pulse heights or preset time into 256/512 channels. Panel-mounted switch controls all operating modes.

For complete details request Bulletin 20617

FLEXIBILITY

INTERCHANGEABLE MODULES permit maximum analyzer flexibility, optimum reduction of spectra variables.

For complete details request Bulletin: Modules and Accessories



EARLY BIRD SPECIAL—Fast delivery available on limited number of earlier vacuum tube models at tremendous savings. Write today for a quotation.

RCL

RADIATION COUNTER LABORATORIES, INC.

5121 West Grove Street, Skokie, Illinois, U.S.A. Phone: YOrktown 6-8700

HOW TO EVALUATE MASTER SLAVE MANIPULATORS

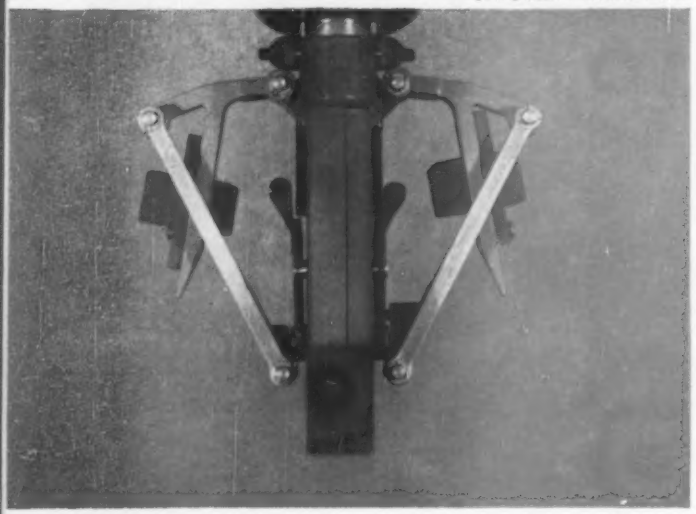
Here are questions and answers and a check list of features with which you can compare manipulators. It will help you to select the models best suited to your installation and requirements.

OPERATING CAPABILITIES

	Model 8 MSM	AMF SDMSM	AMF HDMSM
X-MOTION (Side to side)	30 LBS. (at normal operating extension)	100 LBS.	100 LBS.
Y-MOTION (back and forth)	30 LBS. (at normal operating extension)	100 LBS.	100 LBS.
Z-MOTION (up and down with load hook)	65 LBS.	65 LBS.	100 LBS.
MANIPULATION	5 LBS.	10 LBS.	40 LBS.

SELECTOR LEVER

OPPOSED FINGER GRIP



1. Is the biggest machine the best?

First of all, what are your needs? The full range of operation requirements should dictate your choice. There's no point in using a sledge for tack hammer service or vice versa. That is why AMF offers both a standard-duty and a heavy-duty manipulator. However, the heavy-duty "doubles in brass," providing standard-duty dexterity and heavy-duty load capacity.

2. Suppose my requirements change?

They very well might, and rapidly. This is why the AMF Heavy-Duty machine handles light tasks as well as heavy with a 1:1 ratio in normal operating range. Why change manipulators when flipping a selector lever will do the job?

Also, AMF Atomics can convert Model 8 manipulators for heavy duty service in minimum time with minimum expense.

3. What makes a manipulator a true "Master Slave" and what difference does it make?

If the tong movement exactly parallels the operator's (master's), the manipulator and operator have a master-slave relationship. That is why AMF Atomics manipulators have an *opposed finger* rather than a pistol grip, which was investigated and discarded by AMF some years ago. The pistol grip locates the operator's hands lower, and rotation around the wrist results in unnatural hand positions. Further, the increased distance from wrist to pivot point creates unfavorable leverage and makes weights extremely difficult to handle.

4. Steel or aluminum for boom and master trunk tubes? Which is better?

The comparison is this: steel has greater strength, but also much greater weight and therefore makes for operator fatigue. The heavier the boom tubes, the more counterweighting is required and, consequently, total inertial weight is still further increased. The question is, *how much strength is necessary?*

AMF Atomics believes that aluminum, because of its low weight (and high strength), is far preferable. It *does the job* (see chart) without need-

lessly burdening the operator. There's less weight to start moving, less to stop. Result: ease of operation without penalty!

5. What is the best rate of closure for the tongs?

Let's say first that the faster the rate of closure the less "feel" the operator has. This results from the force disadvantage in movement ratios higher than 1:1—say 1:2, 1:3 or 1:4. For light work the extra operator pressures are extremely tiring.

This is why AMF Atomics uses a 1:1 ratio for initial movements combined with a "double squeeze" system for increasing leverage. Again a 1:1 ratio is true, "normal," master-slave relationship.

6. What sort of service should I expect from my supplier-manufacturer?

Operations in nuclear science and industry can be "critical," not only in the special nuclear sense but also in the universal meaning of the term. Breakdowns can be *doubly* critical. That is why AMF Atomics takes these special steps and offers the following services:

a. AMF Atomics, by design and skilled manufacture, assures that the very minimum of service will be needed.

b. It provides a complete operation, maintenance and spare parts manual. The implications for minimum down-time are obvious.

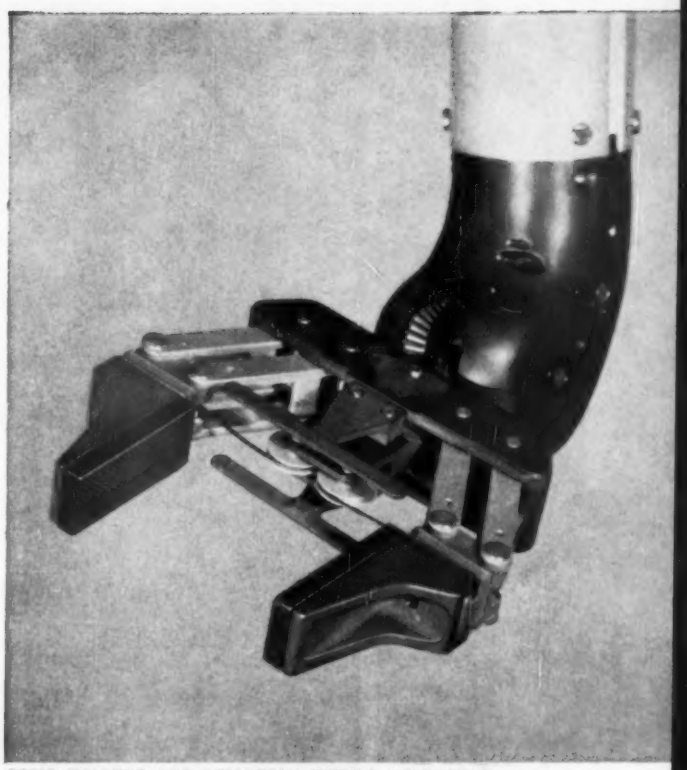
c. AMF provides technical field service that is constantly on call.

7. What about special requirements?

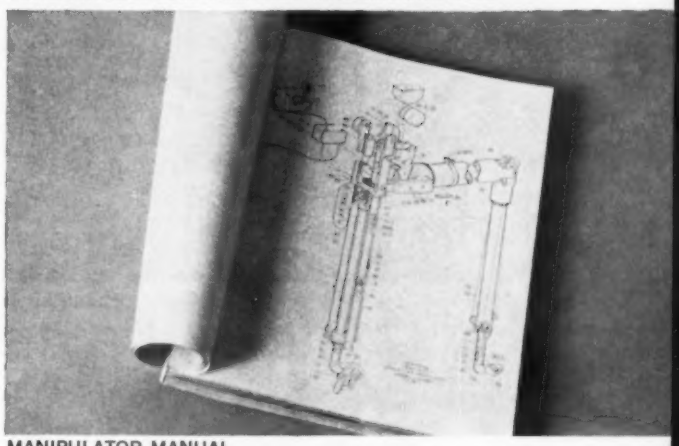
The wide range of AMF standard stock accessories eliminates most special requirements. However, if your problem is special, our engineers work with you to find the best solution at the lowest price.

AMF Atomics activities reach into all areas of nuclear science and technology, including: Research and Test Reactors; Reactor Refueling Equipment; Power Reactor Design; Nuclear Fuel; Remote Handling Equipment; Manipulators; Fuel Processing Equipment; Isotope Applications; Shielding and Radiation Studies; Reactor Control Systems; Training Reactors.

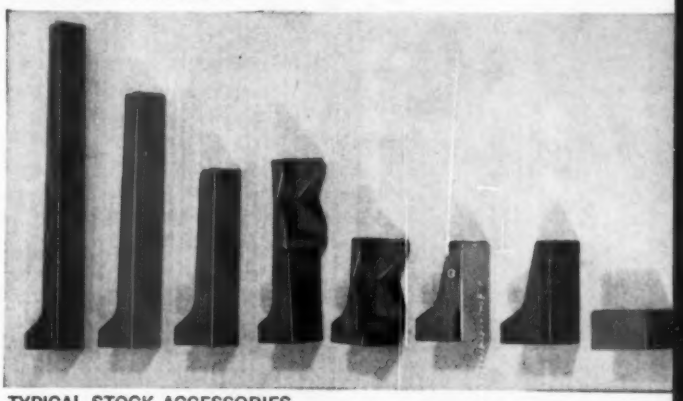
Please write for detailed information about any of these AMF Atomics products or services.



TONG FINGERS ARE REMOTELY INTERCHANGEABLE



MANIPULATOR MANUAL



TYPICAL STOCK ACCESSORIES

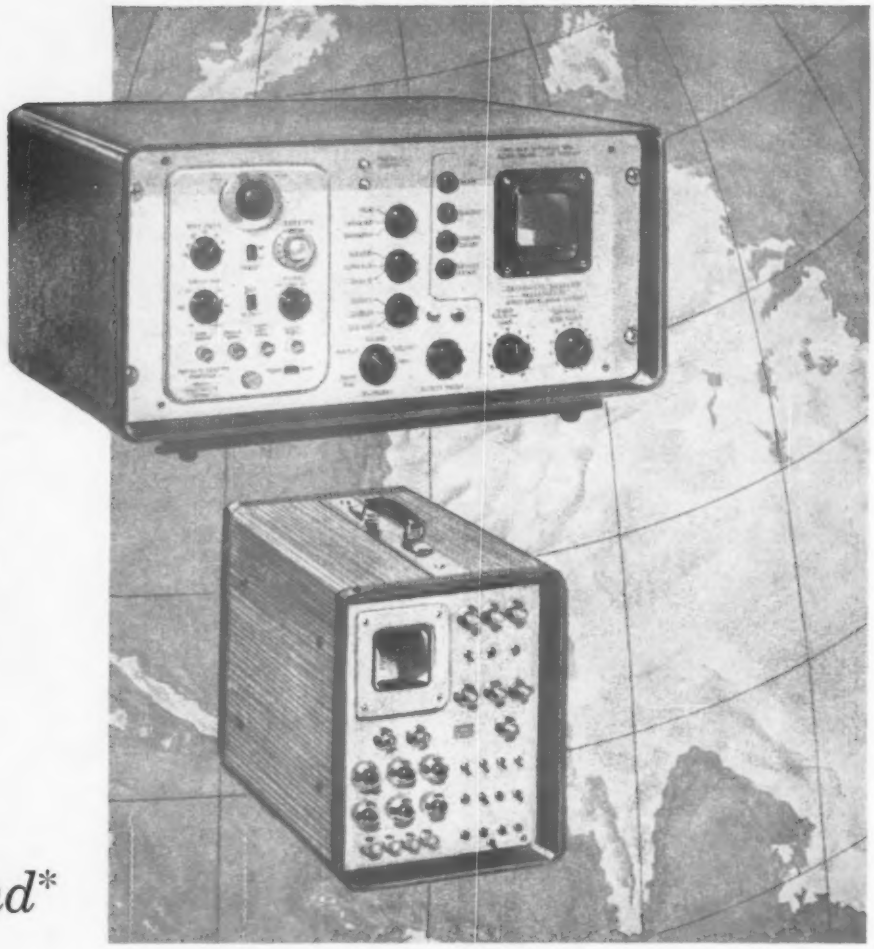
AMF ATOMICS

A Division of American Machine & Foundry Company
140 Greenwich Avenue, Greenwich, Connecticut

AMF

EXPERIENCE, PERFORMANCE ACROSS THE BOARD... ACROSS THE WORLD

*What's good for nuclides in New Haven is good for those in New Zealand**



We think the reason people all over the world buy TMC pulse analyzers is pretty much the same reason they're widely purchased and used here: competently designed, bug-free circuits . . . straightforward operation with the same performance and stability today as yesterday . . . easy access to sub-assemblies and uncomplicated servicing if needed. Another way of putting it is the instruments give the user the information he wants in *his* work — with predictable behavior—regardless of where his site, lab or plant may be located. Here are two current examples:

The TMC CN-110 256 channel analyzer offers 7 interchangeable plug-in logics, including pulse height, time of flight, pulsed neutron, multiscaler, mass spectrometer, and coincidence pair. This widely used and thoroughly proven analyzer (over 100 units have been delivered) employs all-transistorized circuitry. Analog, binary, octal and decimal readout may be used. Data can be recorded on strip chart or X-Y recorders, printed paper tape, punched paper tape, or punched cards.

The Model 404 is a compact, 400-channel analyzer you can use anywhere there's a wall outlet and one square foot to put it down. It has a magnetic core memory that can be used in sub groups of two or four; four separate inputs and associated amplifiers; internal pulse routing circuitry; pushbutton data transfer and display overlap; power requirement of *only 25 watts*, and many "system" advantages. While its versatility is a little less than the CN-110's, so are its size, price and purpose quite different from the 110's. Each does its *own* job well.

**Also wherever TMC Pulse Analyzers are used . . . in Canada, Brazil, Australia, Japan, Yugoslavia, France, Italy, Germany, Belgium, Sweden, Denmark, Switzerland, Israel, Formosa . . . as well as the United States.*

WRITE FOR LITERATURE.

TMC **TECHNICAL MEASUREMENT CORPORATION**
441 WASHINGTON AVE., NORTH HAVEN, CONN. • CE 9-2501

MIDWEST NUCLEAR FITTINGS GO TO SEA IN OUR ATOM-POWERED FIGHTING FLEET

Midwest nuclear fittings have grown up with America's atomic-powered navy development program. They were used in the prototype of the submarine Nautilus, first-born of the nuclear fleet. Today, they're cruising on or beneath the seas in such vessels as the cruiser Long Beach, first nuclear-powered surface ship, the aircraft carrier Enterprise, the destroyer Bainbridge and a host of atomic submarines.

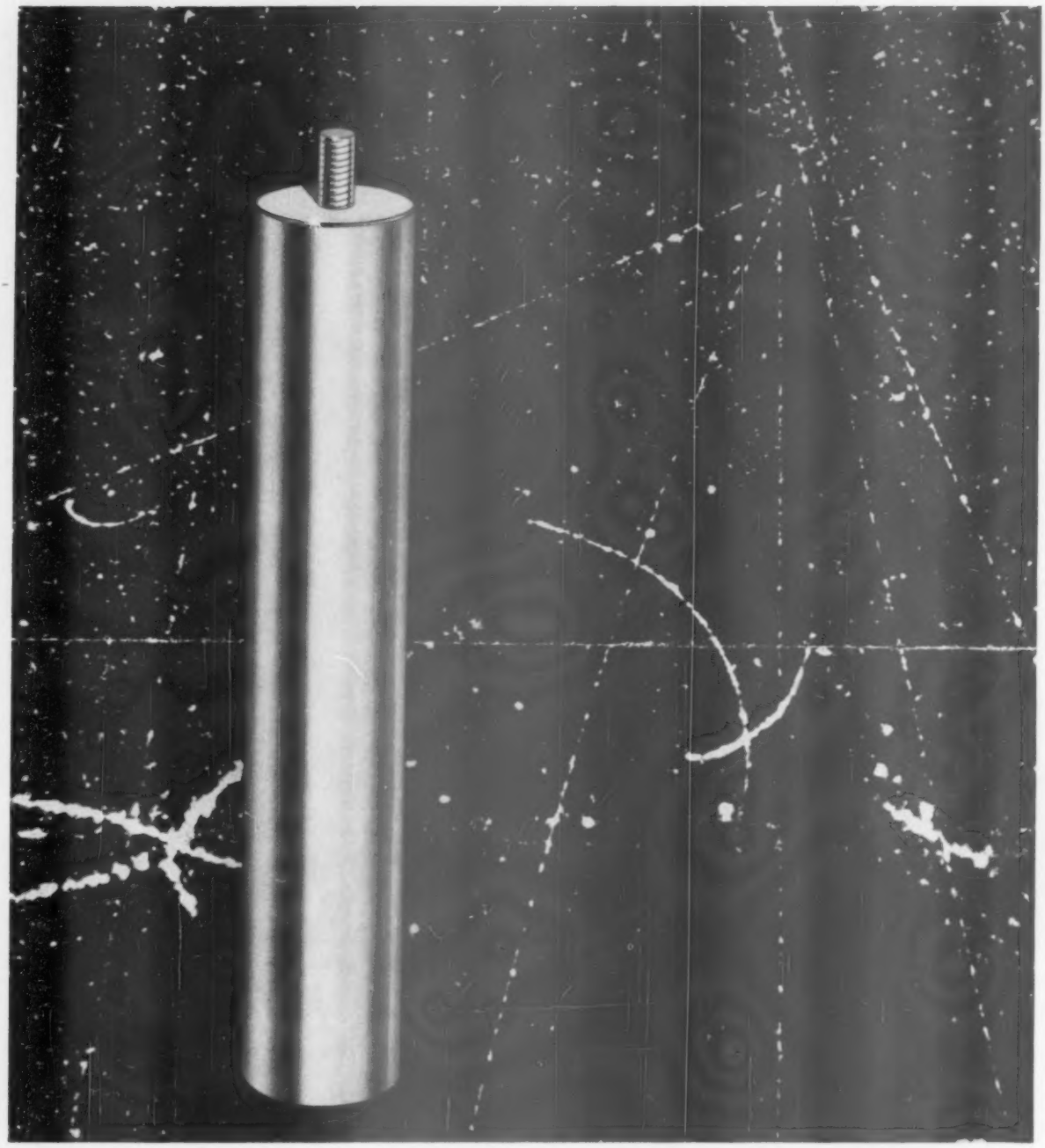
Fittings for these seagoing nuclear power plants were formed from stainless steel, stainless clad steel and Inconel, under rigid quality control and to the extremely stringent specifications for marine reactor piping.

In addition to these special fittings, Midwest produces a complete line of stock fittings and flanges, in carbon steel and alloys, for marine use.

Write today for Midwest Bulletin 60-A, "Critical Piping for the Nuclear Age," describing Midwest's manufacturing, fabrication and erection facilities. The 20-page booklet includes numerous examples of nuclear installations in which Midwest products and services were used.

MIDWEST PIPING

A DIVISION OF CRANE CO.
1450 S. SECOND STREET
ST. LOUIS 4, MISSOURI



Westinghouse leadership in neutron detectors is attested by one outstanding fact: more Westinghouse neutron detectors are in use today than all other makes combined. With more than 50 different detector designs, Westinghouse offers the most complete line to meet your specific application . . . for marine propulsion . . . space probes . . . or land-based reactors. For further information, call or write: Westinghouse Electric Corporation, P.O. Box 284, Elmira, N.Y.

You can be sure . . . if it's **Westinghouse**

DYNAMITRON / PARTICLE ACCELERATOR

wind tunnel for outer space

Both government and industry have chosen Dynamitron accelerators or Dynamag Ion Sources for space environmental research.

- **NASA** — Langley Research Center
- **NASA** — Lewis Research Center
- **GENERAL DYNAMICS CORPORATION** — Convair Division
- **GRUMMAN AIRCRAFT ENGINEERING CORPORATION** — Research Department

RADIATION DYNAMICS, INC.

Westbury Industrial Park
Westbury, Long Island, N. Y.

For detailed information, write for "The Dynamitron in Space Research"

LEAD

Pb

NEW YORK, Sept.1 -- MORE THAN 25 MILLION POUNDS OF ASARCO CAST AND ROLLED LEAD HAVE BEEN USED FOR RADIATION SHIELDING IN PERMANENT AND MOBILE NUCLEAR REACTORS SINCE THE BEGINNING OF THE ATOMIC POWER ERA.

ASARCO

Asarco pioneered techniques that produce lead castings of such uniform high density that even gamma rays cannot find surface pinholes to penetrate. As a result, Asarco is a major fabricator of lead in the many forms required by radiological, chemical, refining, atomic, construction and other industries. Many of the mobile reactors in use today are shielded by Asarco patented interlocking lead bricks, and its lead sheet, plate and castings are found in permanent reactors, isotope packaging and atomic storage, shipping and disposal containers.

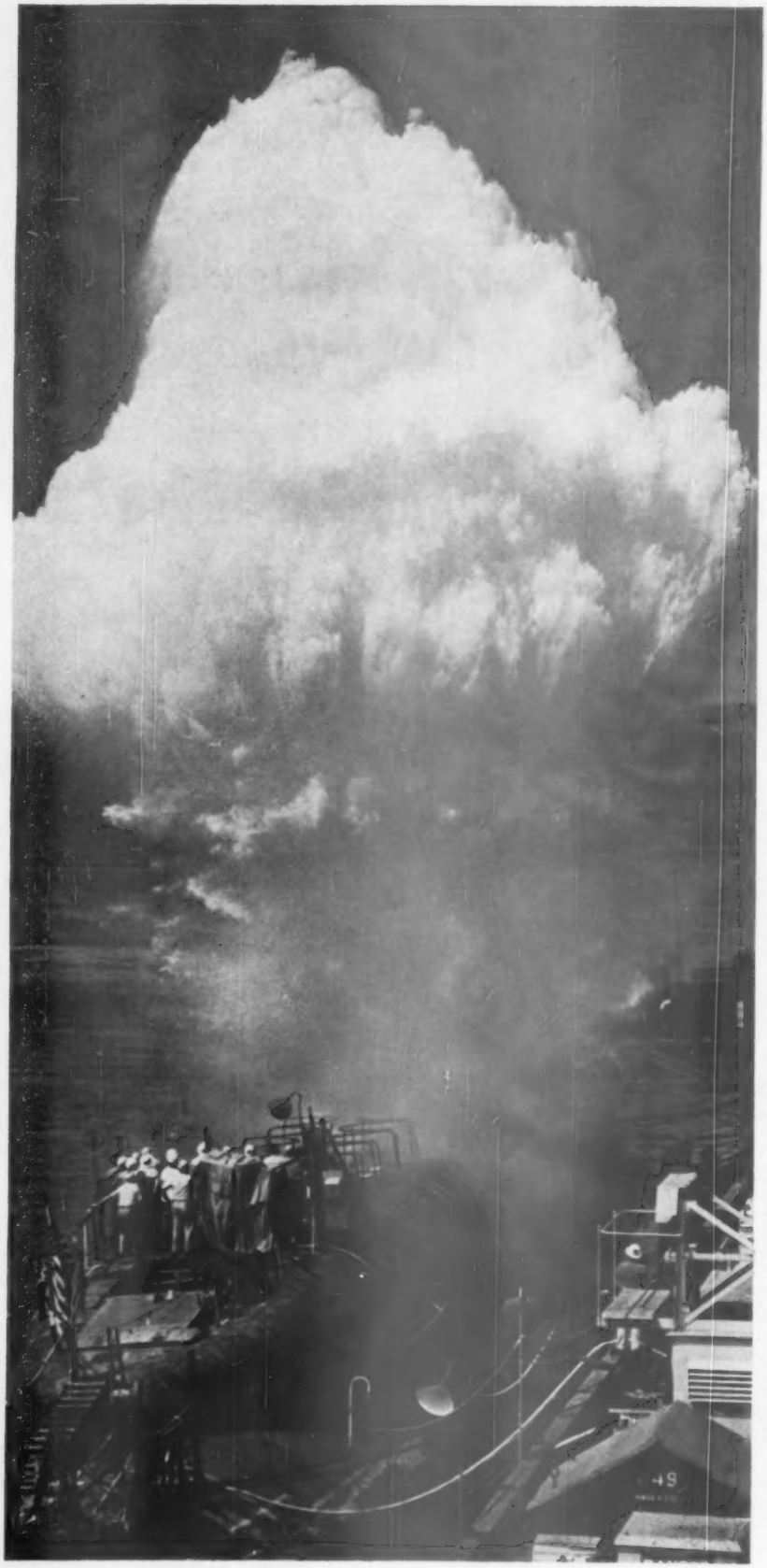
Asarco is the world's largest refiner of lead and knows more about it than any other company. New applications are being sought constantly through fundamental and applied research. Asarco high purity lead, 99.999+% pure, is one result of such research.

In addition to ores and concentrates from its own mines, Asarco also smelts and refines lead ores and concentrates produced by independent mines. Asarco also is a major reclaimer of scrap metal. All of these sources assure steady availability of quality lead in quantity under all market conditions.

For more detailed information about lead in all its forms and uses, write American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

Launching an atomic powered submarine with Asarco radiation shielding aboard. Inset shows method of anchoring the sub's lead shielding plates with Asarco lead wool.

American Smelting and Refining Company
120 Broadway, New York 5, N. Y.



NUCLEAR SEAPOWER TAKES ON SUBSTANCE AT NEWPORT NEWS

The attack submarine "Shark," Fleet Ballistic Missile submarines "John Marshall," "Thomas Jefferson," "Robert E. Lee," "Sam Houston" and two others still unnamed, and the aircraft carrier "Enterprise" have established Newport News as the world's largest producer of nuclear-powered ships.

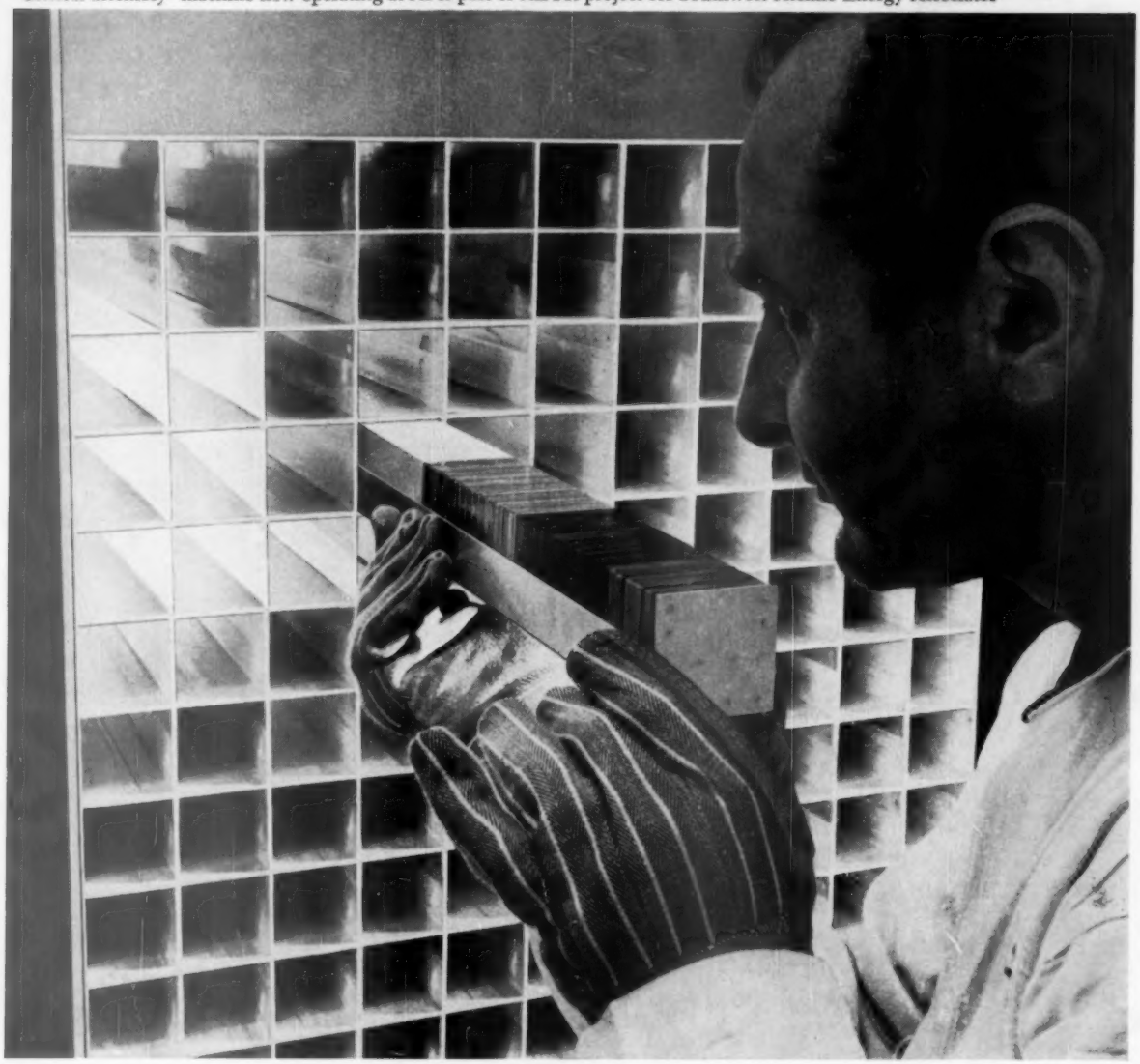
It is a distinction we hold with pride—as evidence of both our versatility and ability to take big challenges in stride.

Whether the job involves nuclear or conventional power—undersea or surface ships—ships for commerce or our country's defense—Newport News has the men, the methods and the machines to do it well.

As we celebrate 75 years of shipbuilding, we fully expect this to be as true in years to come as it is today.

Newport News
SHIPBUILDING & DRY DOCK COMPANY
NEWPORT NEWS, VIRGINIA

"Critical assembly" machine now operating at AI is part of AETR project for Southwest Atomic Energy Associates



The Peaceful Atom

Needed in ten years: 100% increase in world power output

In the dynamic decade ahead, the demand for electrical power will be expanding faster than ever before. To meet this vastly increased need, new and highly advanced concepts are needed. A promising nuclear concept is the Advanced Epithermal Thorium Reactor. The AETR is under active study today by Atomics International for the Southwest Atomic Energy Associates, fifteen investor-owned utility companies. Two other nuclear concepts pioneered by Atomics International are being applied in construction of power stations in Piqua, Ohio, and Hallam, Nebraska, as part of Atomic Energy Commission programs. These are some of the ways AI is helping the power-producing companies of the world double the supply of electricity in the next ten years.

ATOMICS INTERNATIONAL

Division of North American Aviation

Pioneers in the creative use of the atom

World Headquarters: Canoga Park, California, U.S.A. Cable Address: ATOMICS. *Other Offices:* Washington, D.C., U.S.A.; Geneva, Switzerland. *Affiliated with:* INTERATOM, Bensberg/Cologne, Federal Republic of Germany and DYNATOM, Paris, France

custom instrumentation

controls one-megawatt "swimming pool" reactor

The Honeywell control system for the University of Virginia's "swimming pool" reactor combines wide operating flexibility with safe, sure reactor control. The system is custom designed to handle all operating functions of the reactor, and to provide thorough grounding for student engineers in basic nuclear instrumentation.

Rated at one-megawatt, the reactor ranks as one of the most powerful university nuclear facilities in the nation. The reactor core has twenty fuel elements, each with twelve fuel plates made of uranium aluminum alloy. Total fuel charge amounts to about three kilograms uranium, enriched in U-235 isotope.

The reactor is currently used to train graduate students in practical nuclear engineering. Student engineers "learn by doing" under the watchful eye of qualified instructors and skilled technicians. Equally important, the reactor serves as a research facility for the Departments of Biology, Chemistry and Physics, and Schools of Engineering and Medicine.

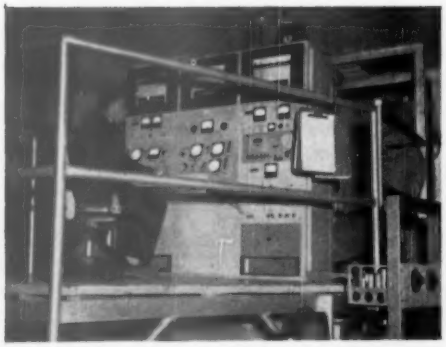
This custom-built control system is merely one example of Honeywell's experience in nuclear instrumentation. From the design and manufacture of components . . . to building complete reactor control systems . . . to installation, startup, and service, Honeywell can help you achieve efficient, economical and reliable control of your nuclear project. Your nearby Honeywell field engineer will be glad to discuss your nuclear instrumentation requirements.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

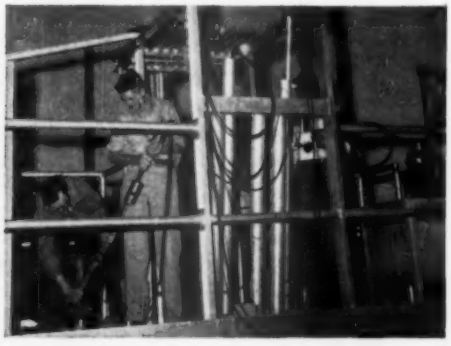
Honeywell

First in Control SINCE 1906

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.



The Honeywell control console is located on a mobile bridge which spans the width of the pool. The bridge can be moved to position the core at any point along the length of the pool. Console instrumentation includes Honeywell ElectroniK 15 recorders (log count rate, linear power, log N), nuclear amplifiers, power set control unit, rod position indicators, and reactor scram annunciator.



The center of the control bridge functions as the nuclear work area. Supported from this point are the core, the control rod drive mechanisms, safety rod magnet assemblies, and neutron counters. Instructors and skilled technicians supervise and assist graduate students in setting up and performing reactor experiments. In this way, student engineers learn practical nuclear physics and reactor technology.

FEATURES

- Made by specialists in corrosion-resistant metals—in the business since 1927.
- Cold formed from forged or wrought metal, eliminating porosity—no castings are used.
- Produced of Stainless Steels 304, 304L, 316, 316L, 347, Monel, Nickel, and Aluminum.
- Stainless Steel, Monel, and Nickel fittings are annealed.
- Ends of all fittings are accurately machine tool cut—not ground.
- Regularly produced in all popular sizes and schedules.
- Made in conformance with A.S.A. and M.S.S. Standards—much closer to nominal dimensions than to permitted tolerance extremes.

We have had more stainless piping experience than any other fitting manufacturer—*since 1927.* And, we are the industry's only specialist in corrosion-resistant welding fittings. What's the dollar and cents value of this to you? Just this: *It reduces your installation and maintenance costs.* Here's why—

Because of our exclusive, patented cold forming process and other production procedures FLOWLINE Fittings are supplied much closer to nominal dimensions than to tolerance extremes permitted in A.S.A. and M.S.S. specifications. This high dimensional accuracy reduces fit-up time and assures optimum welding efficiency.

Because we specialize in corrosion-resistant welding fittings, our methods of forming, annealing, end finishing, etc. put the metal used in FLOWLINE Fittings in the best condition for corrosion resistance. This assures maximum service life.

For specifications of FLOWLINE Fittings write for Bulletins 416 and 417.

FLOWLINE CORP.

World's Largest Manufacturer of Stainless Welding Fittings

NEW CASTLE, PENNSYLVANIA • OLiver 4-5541

HOUSTON 36, 5510 Edith St. MAdison 3-6422
LOS ANGELES 22, 4781 East Third St. ANgeles 8-3676—TWX, LA 1427
NEW YORK 7, 233 Broadway WOrth 2-6669—TWX, NY 1-208
DENVER 4, 1321 Bannock Bldg. KEystone 4-6143-TWX, DN 372
TULSA, 15051 East Admiral Pl. TEmple 5-7575—TWX, TU 1234

F-12

Steam drum—length 67', weight 185 tons—for Dresden Nuclear Power Station of Commonwealth Edison Co. undergoing heat treatment.

No other manufacturer has designed, engineered and built more nuclear steam generators and pressurizers.

Major development projects... specialized pressure vessels... nuclear power plant components... heat engineering services

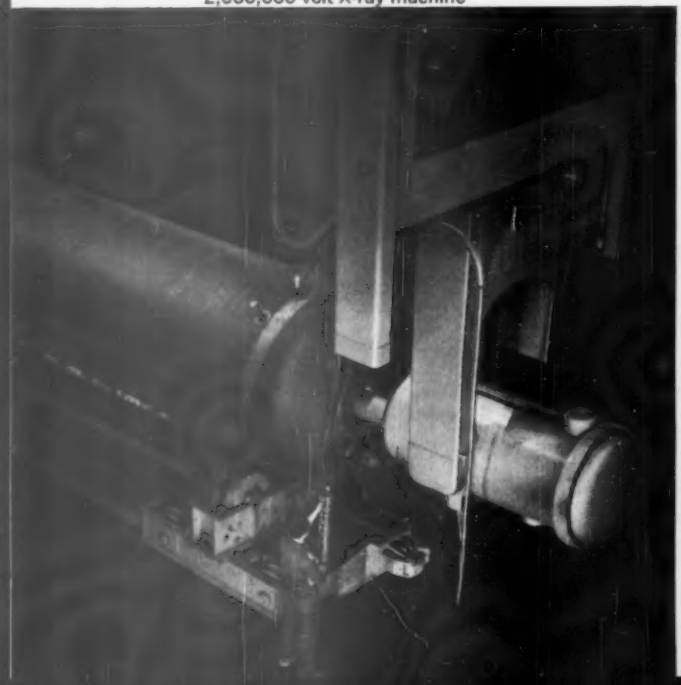
Inquiries may be directed to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y.

FOSTER WHEELER

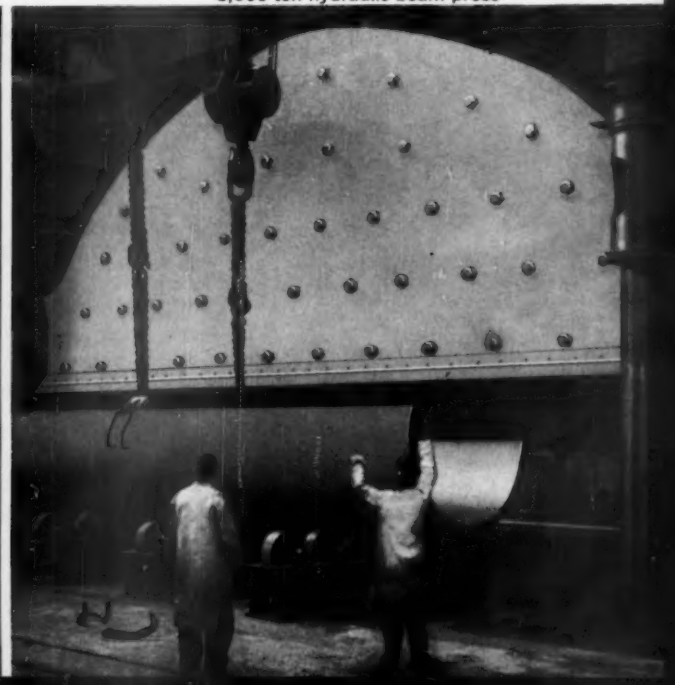
NEW YORK TORONTO LONDON PARIS MILAN TOKYO

Exceptional forming, welding and machining facilities

2,000,000 volt X-ray machine



8,000 ton hydraulic beam press



Outstanding new opportunities in:

Advanced Reactor Technology

One of the main objectives at Atomics International is to expand the knowledge and application of power reactors. If you are interested in this vital area we invite you to share in the progress we are making toward this goal. Areas in which we offer advanced knowledge and intriguing problems are:

Reactor Core Analysis. Complete nuclear core analysis and design including determination of reactivity power shape, control rod worth, interpretation of experimental data.

Hazards Analysis. System safety and hazards studies on compact nuclear power systems for space applications. Background in radiation shielding and radiological hazards evaluation desired.

Heat Transfer. Perform component and overall system studies of the heat transfer systems of several different reactor plants. Specify test requirements and evaluate test results.

Systems Analysis. Analysis and simulation of complete nuclear power plants to develop reliable, unattended, completely automatic control and instrumentation systems, including reactor kinetics, dynamics, and reliability studies.

Control Analysis. Dynamic and control analysis including system start-up and full power operation. BS or MSEE and familiarity with latest analog and digital techniques required.

High Temperature Materials Development. To develop high temperature and radiation resistant electrical insulation systems for electromechanical and electromagnetic control components.

Thermoelectric Materials Development. To develop thermoelectric converter modules. Experience in metal joining techniques desirable, especially brazing. Also experience in ceramic to metal joining.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

For specific details write: Mr. C. J. Newton, Personnel Office,
Atomics International, 8900 DeSoto Avenue, Canoga Park, California

ATOMICS INTERNATIONAL

Division of North American Aviation

EX-CELL-ABILITY...

. . . is craftsmanship. It is the veteran's deft handscraping of precision machine tool slides. It is the young engineer's trained mind solving a design problem. Ex-Cell-Ability is that rare combination of production skill and engineering competence which characterizes Ex-Cell-O Atomics' control rod drives, remote handling equipment and other precision parts and assemblies. Write for literature describing our capabilities, or phone TOwnsend 8-3900; TWX DE-175; cable XLO.

Ex-Cell-O Atomics

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

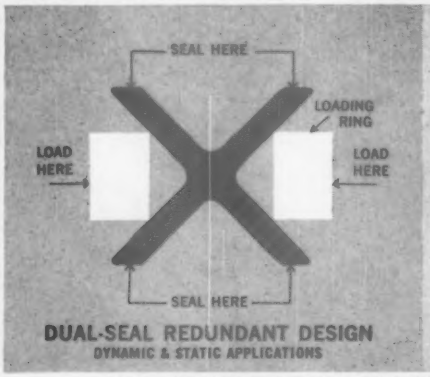
EX-CELL-O FOR PRECISION (XLO)

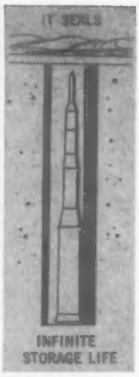
61-55A

BAR-X® SEALS EVERYTHING

AT TEMPERATURES FROM −400° F TO +1500° F!

ANY FLUID—GAS—FUELS—WATER—LIQUID METALS—CRYOGENIC FLUIDS—CORROSIVE FLUIDS
ANY SYSTEM—HYDRAULIC—PNEUMATIC—VACUUM—CRYOGENIC—NUCLEAR





NO CATASTROPHIC FAILURES
INFINITE STORAGE LIFE
UNPRECEDENTED SERVICE LIFE

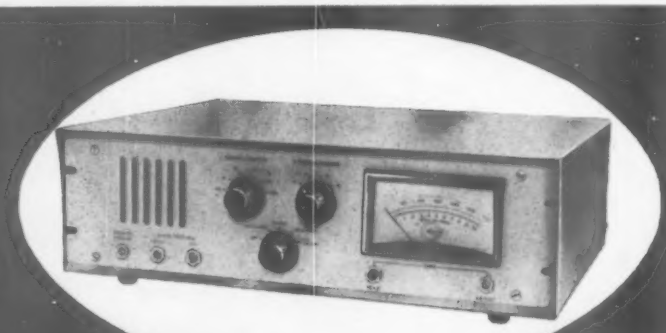
Eliminates critical downtime ■ Very high and very low pressure ■ Easy, foolproof installation (not a mechanism) ■ All-metal—non-contaminating ■ Stable, symmetrical design

WRITE TODAY FOR THE FULL STORY! **SALES ENGINEERS IN PRINCIPAL CITIES.**

Wiggins

E. B. WIGGINS OIL TOOL CO., INC., Dept. H1
3424 E. Olympic Blvd., Los Angeles 23, Calif.
TWX 1403U, Phone AN 9-0181

COUNTability...
RESPONSEability!



NUCOR CRM-593

Transistorized Count Rate Meter

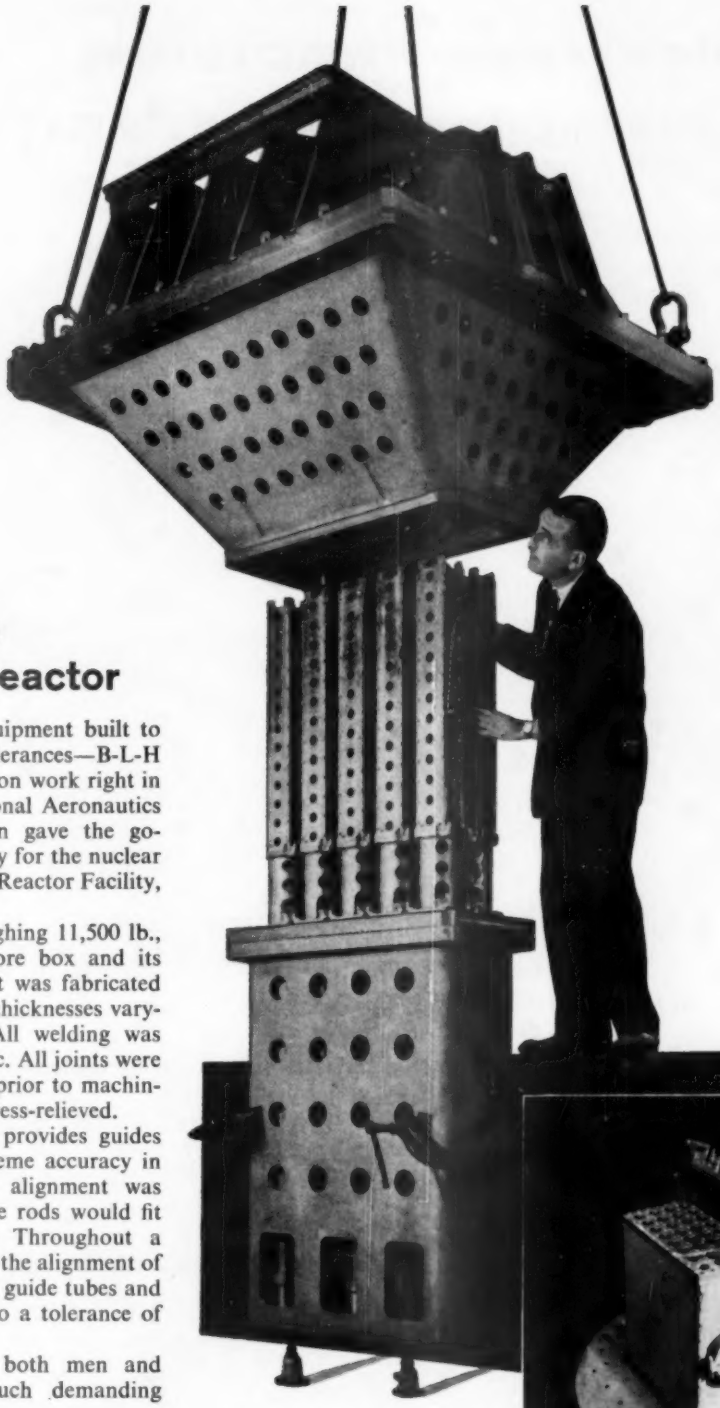
New slim-line design for use with G-M, proportional or scintillation detectors

COUNT THESE FEATURES!

Sensitivity— Better than 1 mv and continuously variable to ¼ volt
High Voltage Supply — 3000 volts
Count Rate Ranges—300/1,000/3,000/10,000/30,000/100,000 cpm
Probable Error Settings — 2, 5, 10 and 15%
Recorder Output— jacks provided for both 0-1 ma. and 0-100 mv. recorders
Transistorized for Dependability

Write today for complete specifications and prices

NUCLEAR CORPORATION OF AMERICA
Instrument and Control Division
DENVILLE, NEW JERSEY



B-L-H and the Plum Brook Reactor

Complex and unusual equipment built to strict specifications, tight tolerances—B-L-H takes this kind of fabrication work right in stride. So, when the National Aeronautics and Space Administration gave the go-ahead on the core assembly for the nuclear reactor in the Plum Brook Reactor Facility, B-L-H was ready.

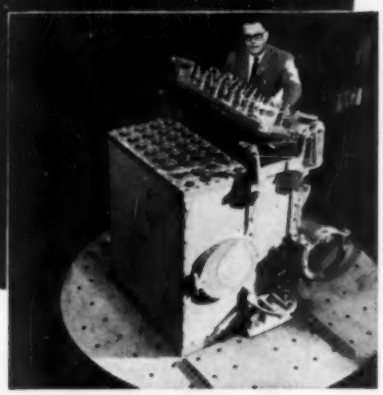
The core assembly, weighing 11,500 lb., consists of the reactor core box and its support. The core support was fabricated of 304-L stainless steel in thicknesses varying from ¾ to 2½ in. All welding was inert-gas shielded metal-arc. All joints were 100% radiographed, and, prior to machining, all weldments were stress-relieved.

Since the core support provides guides for the control rods, extreme accuracy in machining and assembly alignment was essential to insure that the rods would fit precisely when installed. Throughout a total length of 11 ft. 10 in., the alignment of the assembly's control rod guide tubes and core box grids was held to a tolerance of .010 in.

B-L-H's resources—in both men and machines—can handle such demanding jobs efficiently.

A copy of our illustrated Weldment Bulletin 7001 will be mailed to you on request.

Nuclear reactor core assembly fabricated by B-L-H for the Lewis Research Center's Plum Brook Reactor Facility at Sandusky, Ohio, which is now in operation.



Grid lifting mechanism of reactor core assembly shown open.

BALDWIN · LIMA · HAMILTON

Industrial Equipment Division · Philadelphia 42, Pa.

Nuclear-age PRECISION
...major-league CAPACITY!

REACTOR FILTER VESSEL *Diameter: 8 feet... Height: 7 feet*

Fabricated, machined and assembled by Avery and Saul from #4 polish 304 Stainless Steel.

All welds were 100% radiographed to military specifications and the unit was cleaned to nuclear standards.

When you need quality weldments and precision machining, call on us.

QUALITY WELDMENTS

Avery & Saul COMPANY

QUALIFIED WELDERS A.S.M.E.-A.B.S.-NATIONAL BOARD CERTIFICATION- HARTFORD STEAM BOILER INSPECTION

115 RINDGE AVENUE EXT., TEL. UNiversity 4-9070, CAMBRIDGE, MASS.

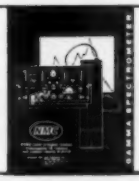
GAMMA ANALYZER model GSS-1B

USING A NEW ANALYTICAL PRINCIPLE

The NMC "Continuous Scan Gamma Analyzer" has greater overall utility than any known system. Consider these advanced features:

- An equal percentage of each peak is analyzed automatically.
- No daily calibration is required.
- A complete spectral analysis is completed in minutes.
- Energies are recorded on a graph calibrated in mev.
- Absolute peak comparisons are made directly regardless of energy differences. Example: Cr^{51} to I^{131} or Co^{60} to Pb^{210}.
- Excellent resolution is obtained over the entire gamma spectrum (0.1 kev to 6 mev).
- The GSS-1 System completes in minutes what normally requires hours.

NUCLEAR
MEASUREMENTS
CORPORATION



Request Brochure 704 or Phone Collect LI 6-2415

INDIANAPOLIS, INDIANA • 2460 N. ARLINGTON AVE. • LIBERTY 6-2415

WILEY BOOKS

PLASMAS AND CONTROLLED FUSION

By DAVID J. ROSE *and* M. CLARK, *both of M.I.T.* In general, this book is concerned both with principles and applications of thermonuclear plasmas. Specifically, it is a well-organized text on plasmas with special applications to thermonuclear processes (the applications are covered in the last three chapters). Two of the most valuable features are its introduction to controlled fusion devices and the inclusion of recent literature, worked into the logical sequence of the text. In short, this is an excellent summary of basic plasma physics. An M.I.T. Press book. *1961. 463 pages. $10.75.*

ELEMENTS OF NUCLEAR ENGINEERING

By GLENN MURPHY, *Iowa State University of Science and Technology.* Concepts and principles necessary for an engineering understanding of nuclear transformation and radiation. Included also is a simplified explanation of modified one-group theory of homogeneous, bare, thermal reactor cores. The book reflects directly the recommendations of the Atomic Energy Commission, the ASEE, and other groups interested in promoting and developing nuclear engineering programs. *1961. 213 pages. $7.50.*

RARE EARTHS

Edited by F. H. SPEDDING *and* A. H. DAANE, *both of Iowa State University of Science and Technology.* Proceedings of a symposium sponsored by the American Society for Metals and the AEC. Expert coverage of the rare earths, the separation and preparation of rare-earth metals and alloys. Surveys what has been accomplished in the field of rare earths, their scientific and engineering applications, and what must be accomplished in the future. *1961. Approx. 615 pages. $14.75.*

Burton, Kirby-Smith, Magee (Eds.):

COMPARATIVE EFFECTS OF RADIATION

A symposium presenting the latest thought of biologists, chemists, and physicists on basic mechanisms of radiation biology. *1960. 426 pages. $8.50.*

Rose: **RELATIVISTIC ELECTRON THEORY**

A bridge between standard quantum mechanics and field theory, offering for the first time a detailed exposition of the Dirac Theory. *1961. 302 pages. $9.50.*

Liverhant: **ELEMENTARY INTRODUCTION TO NUCLEAR REACTOR PHYSICS**

"I can only be enthusiastic about it, and I am certainly convinced that it is a much-wanted and extremely useful work, which will find an enthusiastic readership." F. R. PAULSEN, in *Nuclear Energy. 1960. 447 pages. $9.75.*

Send now for your on-approval copies:

JOHN WILEY & SONS, Inc.

440 PARK AVENUE SOUTH, NEW YORK 16, N. Y.

"LEAD SINCE 1880"

PURITAN BRAND LEAD PRODUCTS

NucLead

(certified 99.99+ pure lead)

for

RADIATION SHIELDING

Lead Bricks—Casks—Sheets

Lead Cast to Specifications

NucLeaD, Inc.

110 Pacific Street, Cambridge, Massachusetts

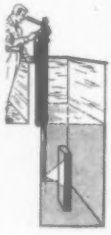
Phone TR 6-7717

Cambridge Smelting Co.
100 Pacific St.
Cambridge, Mass.
TR 6-4807-8

Lead Products, Inc.
Hartford Road
Manchester, Conn.
MI 3-7122

LENOX REMOTE VIEWING 'SCOPES FOR NUCLEAR APPLICATIONS

Lenox leads the way in the development of borescopes and periscopes for the inspection of reactor components and other radioactive parts. Both instruments are supplied with offset optics and integral shielding. Of watertight construction and corrosion-resistant materials, they are manufactured in lengths and diameters to fit the application. Adapters for T.V. and photography available.



◀ NUCLEAR PERISCOPES

For the viewing of remote handling operations such as hot cells, canals, and other hazardous processes. Also available—metallurgical extended microscopes.

REACTOR BORESCOPES ▶

Allow for close-up inspection of reactor's fuel plates, tubes, etc. Interchangeable, illuminated viewing heads and eyepieces permit combination borescope/periscope usage.

When inquiring, please advise length and bore, any bore irregularities, and whether bore is accessible at one or both ends. We will be glad to submit recommendations, specifications and prices.

LENOX INSTRUMENT COMPANY
NUCLEAR DIVISION
2010 Chancellor St. Phila. 3, Pa.
LOcust 8-6611

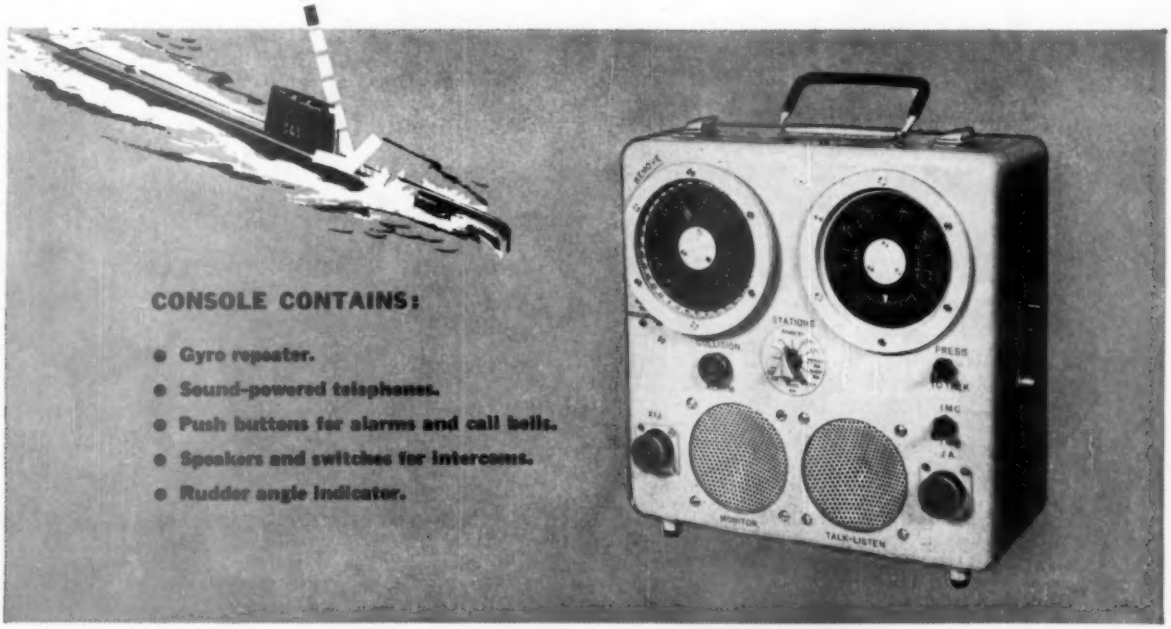
Another example of Bendix capabilities in electronics:

NEW "SUITCASE CONSOLE" BUILT BY BENDIX PROVIDES PORTABLE CONTROL CENTER FOR SUBMARINE COMMAND

This new console lets the submarine commander easily carry his command center to the bridge when the ship surfaces. All instruments needed for conning information and communications are in an 18-lb. package.

On the bridge, the console has a simple, plug-in connection with a single hull penetration replacing the several required by permanently installed controls. Since the "suitcase" is stowed below when the ship is submerged, the individual units cannot fail through flooding or pressure. And, because the units don't need pressure-proofing, each is smaller, lighter and less expensive than conventional equipment.

Portsmouth Naval Shipyard developed and tested the system, and Scintilla Division of Bendix has manufactured and delivered several ship systems. Bendix has produced many types of cables and connectors for underwater applications, airborne and ground-based installations. If you have needs in these areas—write today for complete information.

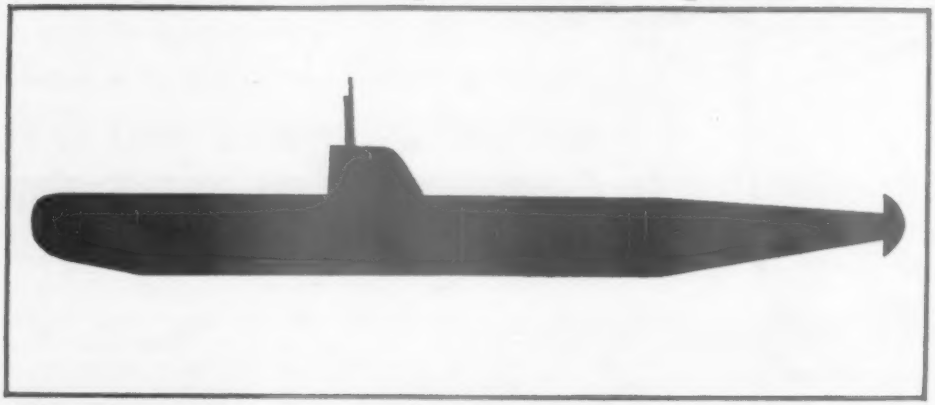


Scintilla Division
SIDNEY, NEW YORK

THE Bendix CORPORATION

Canadian Affiliate: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal 9, Quebec. Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Problem: making water and steam behave predictably in atomic power plants



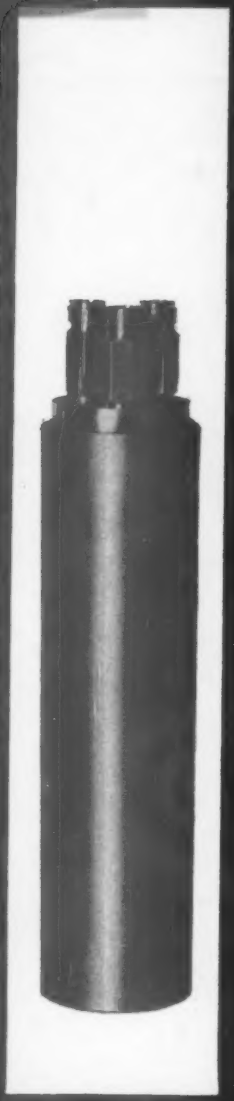
Solution: call on the experience of Hall Laboratories

Experience in dealing with industrial water problems for more than 35 years in every kind of industry... *plus* consultation on water treatment for pressurized and homogeneous reactors... *plus* materials specification and water treatment for an electron accelerator cooling system... *plus* steam quality tests with nuclear power plants... *plus* research project dealings with phosphate solubilities and the effect of water on the metals in nuclear reactors... *plus* training classes for atomic power plant personnel on steam contamination. These, and other similar projects background Hall's ability to provide answers to atomic power plant steam and water problems.

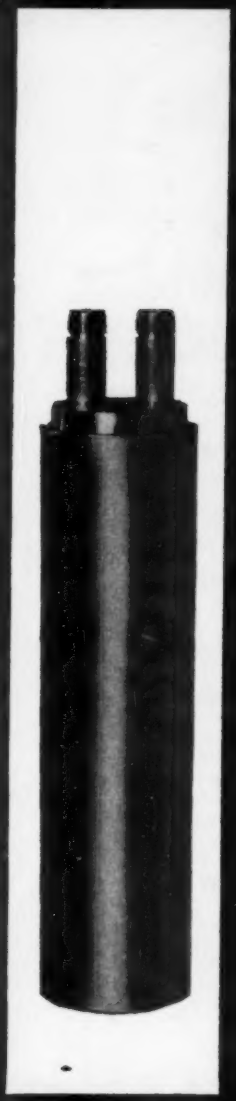
For more information on how Hall Laboratories can be of assistance to you, write or phone: Nuclear Power Division, Hagan Center, Pittsburgh 30, Pa.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

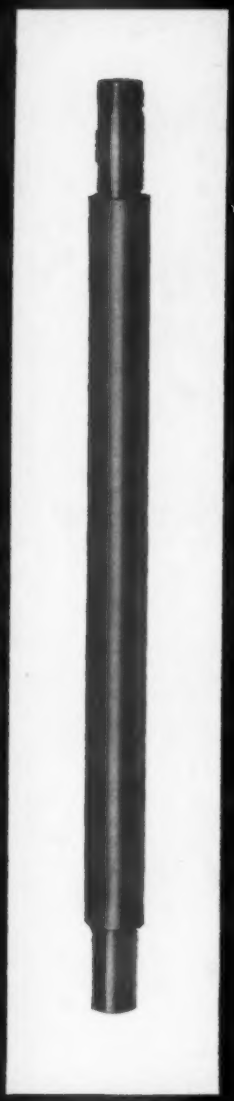
HAGAN DIVISIONS: CALGON COMPANY • HALL LABORATORIES • BRUNER CORP.



Gamma Compensated Ion Chamber



Uncompensated Ion Chamber



Proportional Counter

Miniature In-Core Ion Chamber

General Electric neutron detection chambers are designed, developed and built by the manufacturers of complete reactor systems. They have been proven in operating reactors throughout the world. Write for details today—Section 143-01, General Electric Company, Schenectady 5, N. Y.

NUCLEAR ELECTRONIC PRODUCTS SECTION

GENERAL ELECTRIC

SAN JOSE, CALIFORNIA

RCA VICTOR, CANADA, introduces a wide variety of SILICON JUNCTION

Nuclear particle detectors

WITH OPTIMUM GEOMETRY, HIGH RESOLUTION, LARGE AREA DETECTION

RCA Victor announces a wide variety of new types of silicon junction nuclear particle detectors.

The electrical specifications have been improved and the prices of many of the detectors have been reduced.

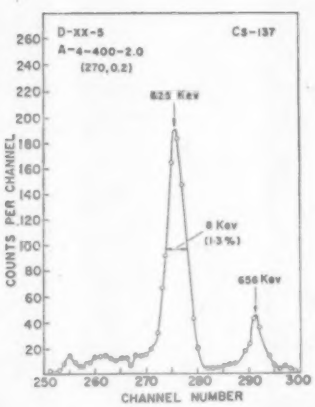
These solid state detectors can be used for alphas, protons, and beta particles.

Please send for our brochure for further details. Inquiries for production quantities are invited.

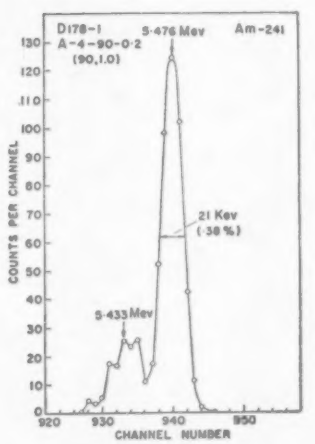
TYPE*	LEAKAGE CURRENT uAmp.	SYSTEM NOISE KEV.	RESOLUTION for 5.5 Mev. Alpha (f.w.h.m. kev.)
A-3-25-0.2	.3	20	50
A-3-75-0.2	.4	15	40
A-3-250-0.2	Under Development		
A-3-25-2.0	.2	15	50
A-3-75-2.0	.25	12	40
A-3-250-2.0	.50	15	30
A-3-400-2.0	1.0	20	35
A-4-25-0.2	.30	15	30
A-4-75-0.2	.40	15	25
A-4-250-0.2	Under Development		
A-4-25-2.0	.25	15	60
A-4-75-2.0	.35	15	45
A-4-250-2.0	.6	15	30
A-4-400-2.0	1.0	20	40
C-3-25-0.2	.4	30	50
C-3-75-0.2	.6	30	40
C-3-250-0.2	Under Development		
C-3-25-2.0	.25	30	50
C-3-75-2.0	.4	20	40
C-3-250-2.0	.6	40	50
C-3-400-2.0	1.0	45	55
C-4-25-0.2	.4	15	50
C-4-75-0.2	.6	15	40
C-4-250-0.2	Under Development		
C-4-25-2.0	.3	15	100
C-4-75-2.0	.5	20	50
C-4-250-2.0	.7	20	40
C-4-400-2.0	1.0	30	50
F-3-25-0.3	1.0	75	150
F-3-25-2.0	1.0	75	150
F-3-75-2.0	1.5	60	120
F-3-250-2.0	Under Development		
F-4-25-0.3	Under Development		
F-4-25-2.0	1.0	75	150
F-4-75-2.0	1.5	60	120
F-4-250-2.0	Under Development		

* A, C or F = 5, 20 or 200 mm² area.
3 or 4 = 10^3 or 10^4 ohm cm. silicon p-type.
25, 75, 250 or 400 = maximum operating voltage.
0.2, 0.3 or 2.0 = diffusion depth in microns

RESOLUTION for protons and beta particles approaches values given under System Noise.



Beta particle detection 5mm² detector; 270 volt bias 0.2 μsec. amplifier rise time.



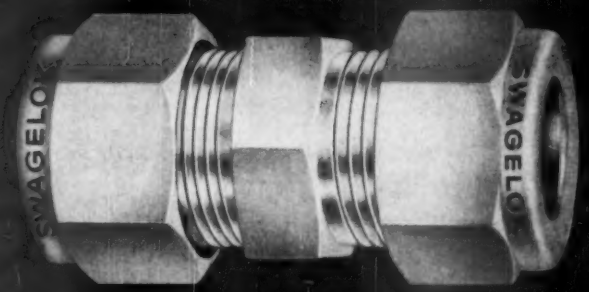
Alpha particle detection 5mm² detector; 90 volt bias 1.0 μsec. amplifier rise time.

Electron Tube and Semiconductor Division — Montreal, P.Q.

RCA VICTOR COMPANY, LTD.

THE MOST TRUSTED NAME IN ELECTRONICS

WHY WAS THIS TUBE FITTING MADE FROM PLATINUM?



This Swagelok tube fitting was machined from Platinum because that is what our customer needed for his nuclear reactor experiments. This is just one of many outstanding examples of Swagelok customer service. The scientist who needed this fitting knew that Swagelok tube fitting reliability would meet the exacting requirements of leak tightness for nuclear work. He also knew that full cooperation in delivering Swagelok in any machineable metal is routine.

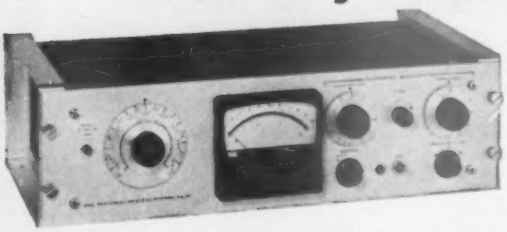
Swagelok, the tube fitting of total dependability, can be provided in any machineable metal or plastic to solve your most demanding problem.

Swagelok® **TUBE FITTINGS**
SOLVE YOUR PROBLEMS

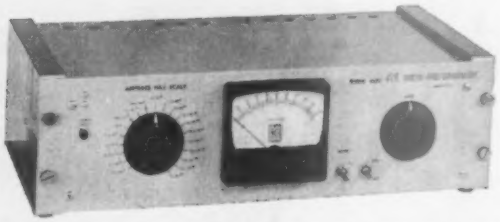
CRAWFORD FITTING COMPANY • 884 EAST 140th St. • CLEVELAND 10, OHIO
CRAWFORD FITTINGS (CANADA), LTD. • NIAGARA FALLS, ONTARIO, CANADA

Keithley Micro-microammeters

for low-level dc measurements



The 415 provides zero suppression up to 100 full scales, current detection of approximately 1 x 10^{-14} ampere, zero stability of better than 2% per day.



Models 410 and 411 provide high sensitivity, low switching transients, high accuracy, fast response and low noise. Drive 5 ma recorders or 50 mv potentiometer types.

The log n circuit of the 420A has only three adjustments and the period circuit one adjustment. Period and current outputs unaffected by normal ambient changes.

NEW MODEL 415 research micro-microammeter has a response time of less than 600 milliseconds to 90% of final value at 10^{-12} ampere where external circuit capacity is 50 $\mu\mu$f. It is ideal for current measurements in ion chambers, ionization gages. Useful with flame and Beta-ray ionization detectors; in gas chromatography, mass spectrometry. **$800.00***

MODEL 410 Recommended for research and control applications where source voltages exceed 300 millivolts. Twenty ranges cover ten decades from 10^{-3} to 10^{-13} ampere. **$490.00***

MODEL 411 Recommended where exceptional zero stability is required and source voltage exceeds 10 volts. Seventeen ranges cover eight decades from 10^{-3} to 10^{-11} ampere. **$535.00***

MODEL 414 Lowest cost instrument for monitoring installations, reactor control, production tests, experiments within its 17 ranges from 10^{-2} to 10^{-10} ampere. **$295.00***

MODELS 410C, 411C AND 414C Contact meters replace panel meters providing economical control or alarm circuitry. **410C—$625.00*; 411C—$670.00*; 414C—$430.00***

MODELS 412 AND 413 Stable log n amplifiers for fluctuating currents from 10^{-5} to 10^{-13} ampere. Uses include reactor monitoring, aerial surveying, film exposure studies. **$485.00***

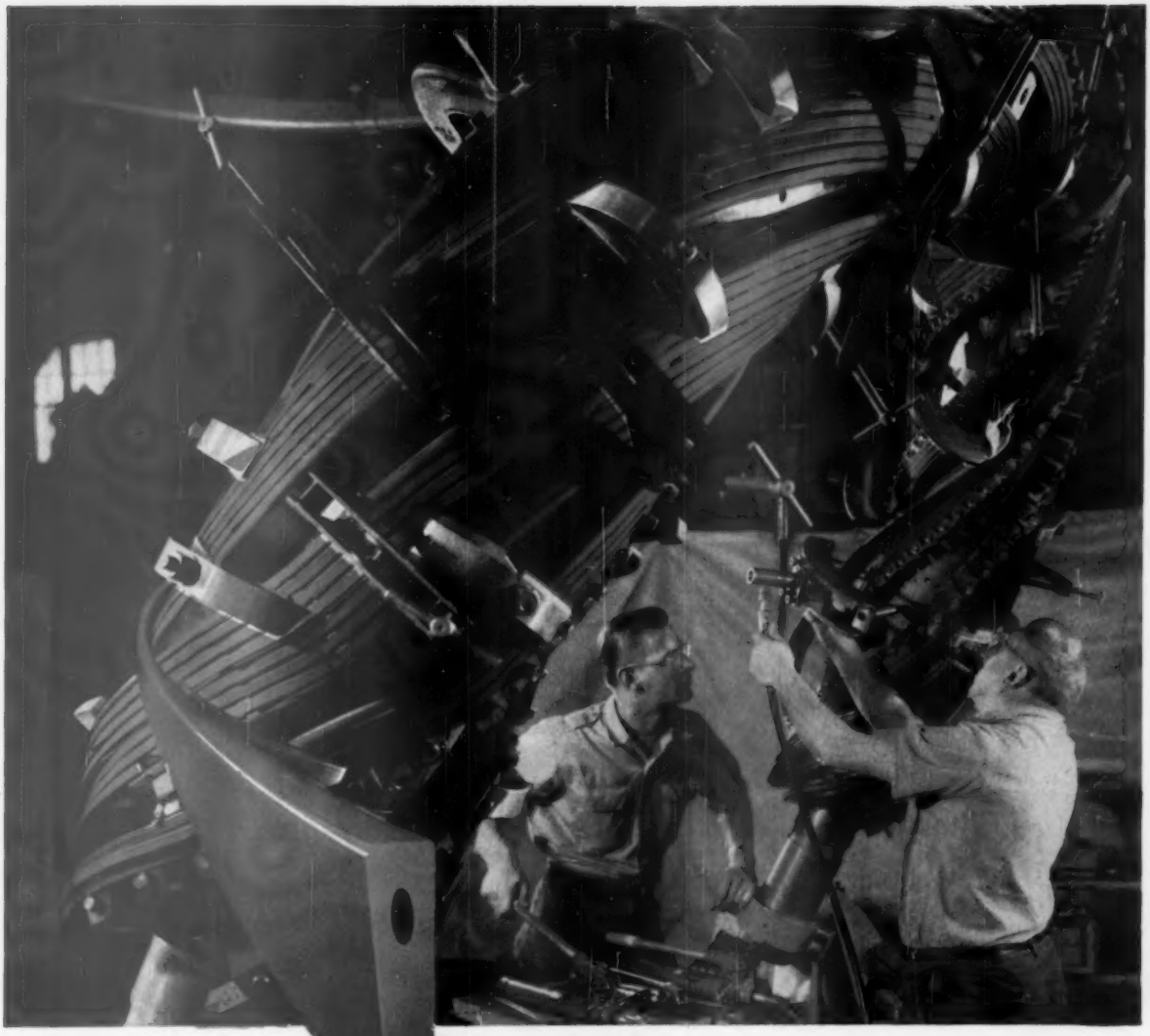
*End Frames (pair for bench use) **$15.00**

MODEL 420A LOG N PERIOD AMPLIFIER A combined log n amplifier and period circuit for the most exacting reactor monitoring. This dual instrument measures current over a seven decade range, from 10^{-6} to 10^{-13} ampere, and reactor period from minus 30 to plus three seconds. Outstanding features are rapid warmup, 5-second recovery from overloads, unsurpassed stability, 10^{-13} ampere sensitivity, adjustable damping. Contact meter models on special order. **$1050.00**

MODEL	RANGE	ACCURACY	ZERO DRIFT	OUTPUT
410/410C†	10 x 10^{-4}, 3 x 10^{-4}, 10 x 10^{-5}, etc. to 3 x 10^{-13} amp f.s.	±2% f.s. on 10 x 10^{-4} to 10 x 10^{-9} ranges; within 4% on others.	After warmup, below 2% f.s. per 24 hours all ranges.	5 v f.s. up to 5 ma. Output noise below 1% of f.s.
411/411C†	10 x 10^{-4}, 3 x 10^{-4}, 10 x 10^{-5}, etc. to 10 x 10^{-13} amp f.s.	±2% f.s. on 10 x 10^{-4} to 10 x 10^{-8} ranges; within 4% on others.	Below 2% per week from cold start, input 10 v or more.	10 v f.s. up to 5 ma. Output noise below 1% of f.s.
412/413††	Single 10^{-7} to 10^{-13} amp, source voltage over 1 v.	Within 0.2 decade, with source voltage over 1 v.	Below 0.05 decade in 24 hours with source voltage over 1 v.	Zero at 10^{-13} amp to –6v at 10^{-7} amp; up to 5 ma.
414/414C†	17 ranges from 10^{-2} to 10^{-10} amp f.s.	Within 3% f.s. 10 ma to 10 mμa; 4% f.s. 3 mμa to 0.1 mμa.	2% per day with source voltage over 1 v.	5 v f.s. up to 1 ma. Output noise below 1% of f.s.
415	10^{-12}, 3 x 10^{-12}, 10^{-11} 3 x 10^{-11}, to 10^{-3} amp f.s.	±2% f.s. 10^{-3} thru 10^{-8} ranges; ±3% f.s. 3 x 10^{-9} thru 10^{-13}.	After warmup, below 2% f.s. per 24 hours all ranges.	1 v f.s. up to 5 ma. Noise below 20 mv rms.
420A Log n AMPLIFIER and PERIOD METER	Single, 10^{-6} to 10^{-13} amp, positive currents only.	Within 0.2 decade.	After warmup, below 0.05 decade in 24 hours.	High level—zero at 10^{-13} amp, –75 v at 10^{-6} amp. Recorder—50 mv f.s.
	Single, –30 to + three seconds.	3% at center scale.		High level — zero for 30 sec. period, 10 v for 3 sec. Recorder—50 mv f.s.

†Contact meter models have same specifications as standard units except for addition of a contact meter relay.
††413 same as 412 except: RANGE, 10^{-5} to 10^{-11} ampere.

KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE CLEVELAND 8, OHIO



PHELPS DODGE

WATER-COOLED TUBULAR CONDUCTOR ...vital part of unique stabilizing winding for C Stellarator!

Phelps Dodge water-cooled tubular conductor is a critical part of the unusual helically coiled field windings being made and to be installed in the experimental C Stellarator device at Princeton University by Allis-Chalmers Manufacturing Company.

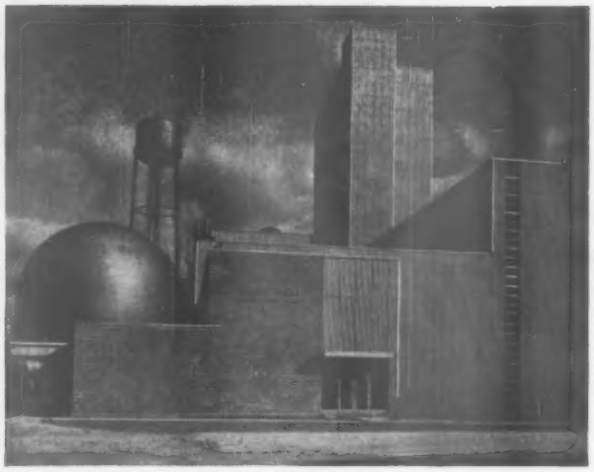
The hollow conductor is extruded and drawn from high purity oxygen free copper. Set within the conductor is an off-center hole for converging a liquid coolant, needed to dissipate the intense heat generated by high currents in the coils of the C Stellarator.

Phelps Dodge has pioneered and developed the design and manufacture of off-center tubular conductors. As a result, only Phelps Dodge produces these tubular conductors in a variety of shapes to fill a wide range of requirements.

PHELPS DODGE COPPER PRODUCTS CORPORATION
300 Park Avenue, New York 22, N.Y.

P MINE TO MARKET D

Exterior View of the Enrico Fermi Atomic Power Plant, Built Near Monroe, Mich. by The Power Reactor Development Corporation.



G-R

First of its kind

VERTICAL ONCE-THROUGH INVOLUTE TUBE

Liquid Sodium Heated Steam Generator

Installed at Enrico Fermi Atomic Power Plant

Conceived and engineered by Griscom-Russell and fabricated in the Griscom-Russell plant, this new type of sodium heated steam generator underscores the ingenuity of Griscom-Russell designers and fabricators in pioneering new, uncharted areas of heat transfer. The involute curved tubes, with U-bends to make 14 horizontal passes between the thermal shield and shell, present even tube spacing to the sodium flow to promote even flow distribution, assure high heat transfer and avoid interferences from thermal expansion.

Three of these new generators of identical design and construction are completing final tests at the Enrico Fermi Atomic Power Plant. Each provides 10,962 square feet of effective surface, and will transfer 489,000,000 BTU/Hr.

For more complete description of these new units, and views of their shop fabrication, write for the Winter 1960-61 edition of G-R News. Send for your copy today.

Bottom of a Partially Assembled Tube Bundle Showing the Involute Curve of the Tube Banks.

Griscom-Russell

THE GRISCOM-RUSSELL COMPANY

220 Wetmore Ave. Massillon, Ohio Telephone TE 2-8751

Engineering and Sales Representatives in the Principal Cities

giant guardian...

Four football fields could be laid out on the flight deck of the giant, nuclear-powered U.S.S. Enterprise—the world's largest ship. But size isn't the only dimension that makes the Enterprise outstanding. Pressurized water nuclear reactors, producing over 200,000 horsepower, will drive her at speeds in excess of 25 knots. She will be able to sail the seven seas for several years without refueling.

Carlson corrosion and heat-resistant stainless steel plate was used in this huge Attack Aircraft Carrier, and in her nuclear power plant. The builders of the Enterprise have confidence in the stainless plate produced by Carlson specialists. Exacting quality standards and dependable delivery result from such specialization.

Whether you are building a gigantic ship, a nuclear power plant, or corrosion-resistant process equipment, we can help you make it best. For practical assistance in filling your requirements for stainless plate in a wide range of grades and sizes, contact Carlson.

Our new booklet, "Producing Stainless Steels . . . Exclusively," is available. Write for your copy now.

Photograph of the launching of the U.S.S. Enterprise.
Courtesy of Newport News Shipbuilding & Dry Dock Co.

OFFICIAL U.S. NAVAL PHOTOGRAPH

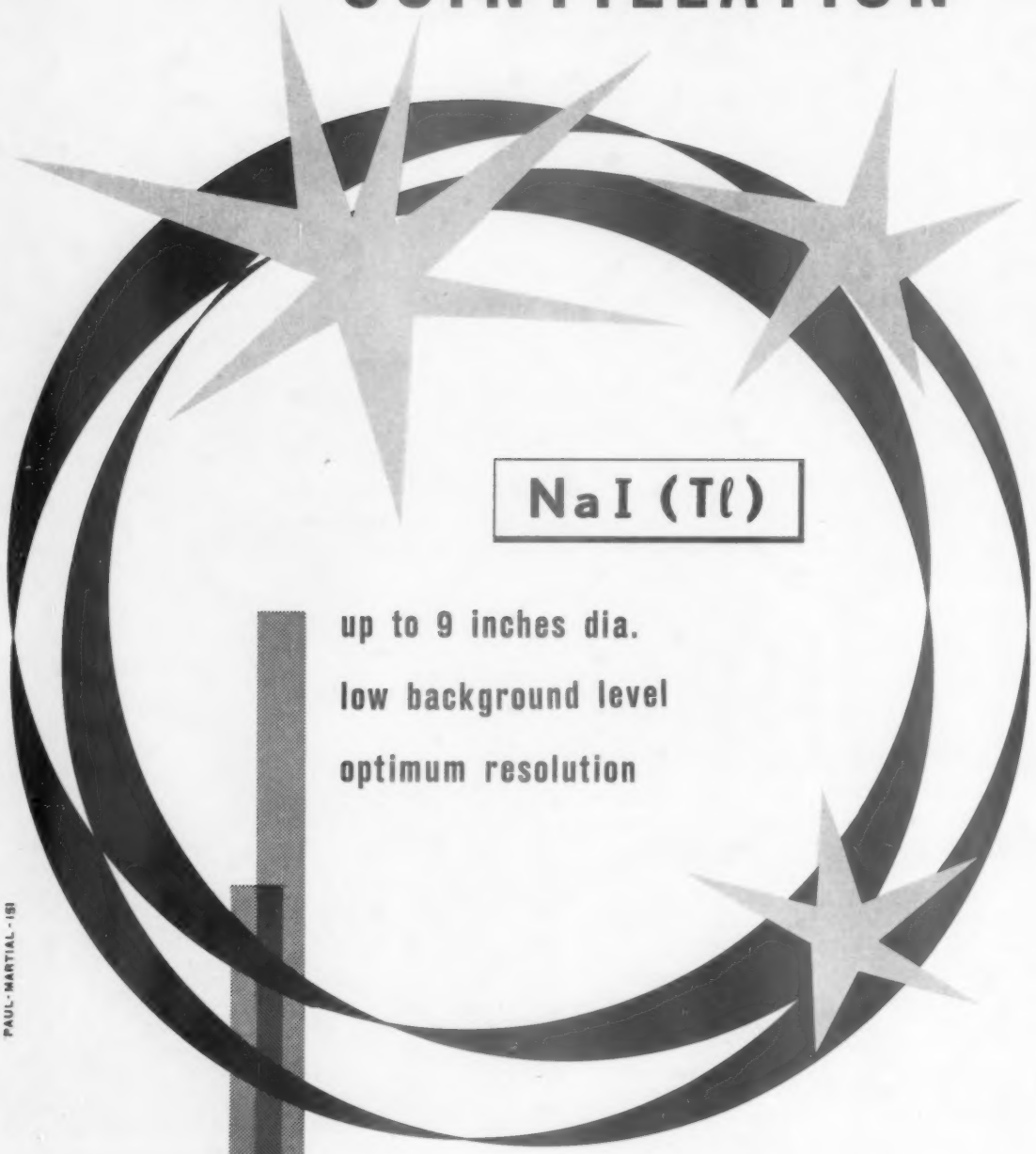
G.O.CARLSON Inc.

Producers of Stainless Steel

138 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

Plates • Plate Products • Heads • Rings • Circles • Flanges • Forgings • Bars and Sheets (No. 1 Finish)

SCINTILLATION



NaI (Tℓ)

up to 9 inches dia.

low background level

optimum resolution

PAUL-MARTIAL - 151

QUARTZ PRODUCTS CORPORATION
688 Somerset Street
PO Box 628
Plainfield - New-Jersey
Tel.: Plainfield 7-4545

all organic and inorganic phosphors

QUARTZ & SILICE

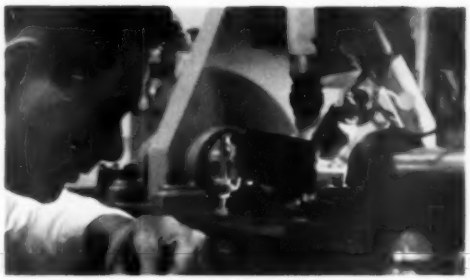
SOCIÉTÉ ANONYME AU CAPITAL DE 5 495 000 NOUVEAUX FRANCS

8, RUE D'ANJOU, PARIS 8e. TÉL.: ANJ. 17-36. TELEX: 27078 SILIS PARIS

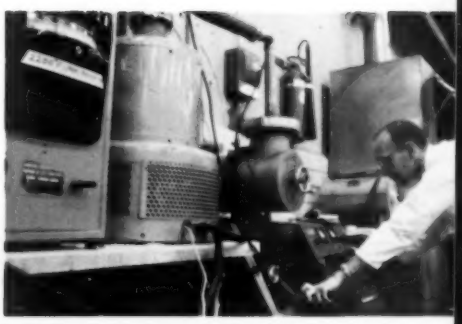
We have agencies in following countries: Austria • Belgium • Denmark • Finland • Germany Holland • Ireland • Italy • Japan • Norway • Spain • Sweden • Switzerland

Why Westinghouse is one of world's leading suppliers of nuclear fuel elements and complete cores

Quality Control. High sensitivity, immersion ultrasonic inspection of tubular and plate fuel elements detects flaws and simultaneously provides written records. Other special quality control equipment includes x-ray, chemical, and metallographic laboratories, eddy current and leak testers, and panoramic cameras for filming internal surfaces.



Rods and Assemblies. This technician is welding a stainless steel fuel rod. Westinghouse successfully fabricates aluminum, zircaloy and stainless steel rods and assemblies. Rods can be up to 1" in diameter and up to 130" long. Assemblies can be up to several thousand pounds.



Fuel Development Laboratory. Each job is completely pre-engineered in a commercial fuel development laboratory. This engineer is sintering cermets in an experimental furnace with instrumented vacuum unit. Laboratory has equipment for development work on all types of potential fuel materials and processes.

Modern Equipment. Facilities include pre-sintering and sintering furnaces (shown above), special vacuum welding boxes, vacuum annealing and vacuum induction melting furnaces, autoclaves for corrosion testing, rolling mills for hot and cold rolling, brazing equipment, brake presses for tube forming and plate bending. Other special production equipment includes a 48' high core assembly room with complete optical alignment and gaging equipment.

Atomic Fuel Department. Westinghouse provides industry with a completely equipped, integrated fuel fabrication facility, located at Cheswick, Pa. Products include pellets in any enrichment, pellet loaded and plate-type fuel elements, core components and completely assembled nuclear cores.

High Quality Pellets. Westinghouse can produce solid, hollow or spherical pellets, in sizes from .100" to approximately 1". A.F.D. has three compartmented pellet lines capable of simultaneously producing UO_2 pellets of three different enrichments.

Electron Beam Welder. This 48" diameter, 28' long vacuum chamber encloses a 2 kw, 150 kv electron beam welding head. Unit is capable of welding pieces up to 24" in diameter, 10' long, at speeds up to 100" per minute. Equipment is used for welding aluminum fuel elements and permits closely controlled welds in refractory metals.

JI-59504

Westinghouse

Nuclear-Chicago's new family of liquid scintillation counters—

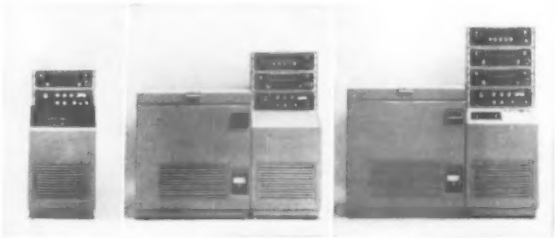
Just months old and already meeting the critical demands of exacting research

Although introduced and well received just last April, Nuclear-Chicago's new family of liquid scintillation counters is already hard at work. At varying levels of work load and within widely differing budgets, these three systems are setting new standards of precision, sensitivity and convenience for demanding scientists.

Research programs expand and equipment needs are upgraded. These new counting systems—compatible with your present, standard scaling instruments—easily accommodate to such growth.

Model 701 is a modestly priced, basic system for manual, room-temperature counting of limited numbers of samples. Uniquely sensitive detector assembly and advanced, transistorized circuitry provide high counting efficiency for carbon-14, tritium, and other soft-beta emitting isotopes. **Model 702** adds a precision-controlled low-temperature chamber for increased tritium-counting efficiency. The third member of the family, **Model 703,** provides fully automatic sample handling and varied options of readout.

Field conversion to upgrade Models 701 and 702 as work load and budget permit requires only the addition, first, of the custom-built, compact cooling chamber, and then, of the automatic sample changer mechanism.



Model 701 **Model 702** **Model 703**

Model 701—manual operation, shown with 8250 scaler

Model 702—manual, temperature-controlled operation, shown with 8250 scaler and 8600 timer

Model 703—automatic, temperature-controlled operation, shown with two 8250 scalers, 8600 timer and 8401 digital recorder

Please request literature on these integrated systems.

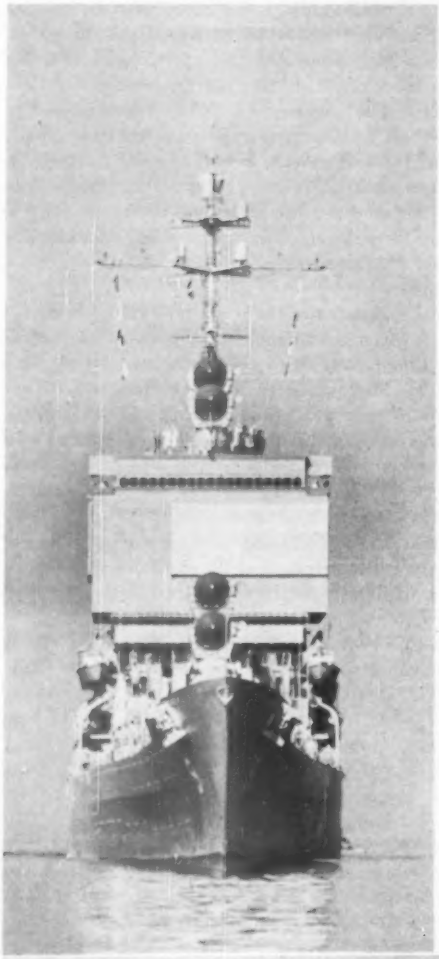
nuclear-chicago
CORPORATION

345 EAST HOWARD AVENUE DES PLAINES, ILLINOIS

Surface Ships Join the Subs in . . .

Our Growing Nuclear Navy

by JOHN E. KENTON, *News Editor*, NUCLEONICS

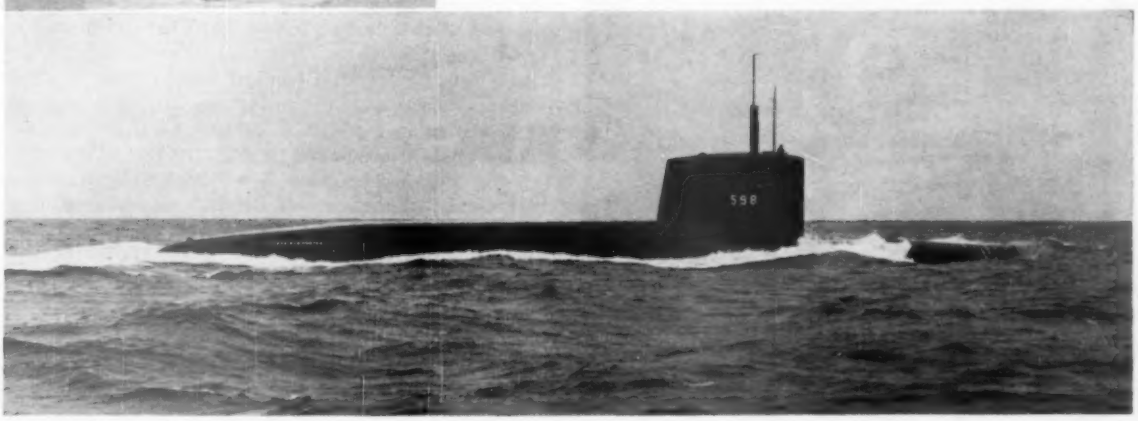


This is the year of the nuclear-propelled surface warship.

Not only is 1961 witnessing the maiden voyages of the first nuclear cruiser *Long Beach* (July 5) and the first nuclear carrier *Enterprise* (late this month or early next) as well as the launching of the first nuclear destroyer-leader *Bainbridge* (to go to sea next fall); 1961 is also the year in which nuclear propulsion, as a standard power source for naval surface ships of the future, appears to be turning the corner—years earlier than had been expected just two years ago.

When NUCLEONICS first surveyed the Navy's massive nuclear program four years ago (NU, July '57, p. 66), the big story was that the nuclear submarine program had moved out of the experimental era and stepped solidly into the production phase. It came then as a surprise to most people not associated with the program that *Nautilus* and *Seawolf*, which had grabbed all the headlines, were already being followed by seven more A-subs under construction and 10 more on order, including the guided-missile sub *Halibut*, the radar-picket sub *Triton*, the hunter-killer sub *Tullibee*, and the revolutionary speedster, the fast attack sub *Skipjack*. However, the Polaris program was still over the horizon. Among surface ships, the keel had been laid for *Long Beach*, *Enterprise* was authorized —and the Navy planned five additional nuclear carriers of the *Enterprise* class, one per year over a six-year period.

Two years later (NU, Sept. '59, p. 73), the submarine program had grown by leaps and bounds, but the surface ship program was circumscribed—not to say halted in its tracks. The Polaris submarine was being hailed as the capital ship of the future, and the fact that both it and the *Skipjack*-type attack sub could use the same nuclear propulsion plant—the Westinghouse-designed S5W reactor—



BAINBRIDGE, first nuclear destroyer-leader [frigate], gets first taste of water at launching at Quincy shipyard

LONG BEACH, first nuclear cruiser, poised for start of first trials. Box-like structure at mast contains new radar

ENTERPRISE, first nuclear carrier, being warped to fitting-out dock after launching last September at Newport News

meant that the benefits of standardization, even of something approaching mass-production, were being felt for the first time in the young nuclear power industry. Twenty-eight S5W reactors were built, under construction or on order then (the corresponding figure today—*for this one reactor type alone*—is 52, including 41 of the improved S5W-2 version of this third-generation naval pressurized-water reactor).

On the other hand, the six-carrier nuclear program had been torpedoed in Congress, and although *Bainbridge* had been authorized as a prototype nuclear destroyer-leader, no follow-ships had been ordered, or appeared likely to be, in any of the three major classes of surface warships. Cost factors, described as from two to four times more expensive for nuclear than for conventionally-powered ships, made expansion of the surface-ship program seem doubtful in the immediate future, and the Navy's top leaders were saying that it would put the first three prototype ships—*Long Beach*, *Enterprise* and *Bainbridge*—through extensive and extended performance tests before making a decision on ordering more.

This spring and summer the pendulum swung 'way out again as new gains in bringing down the cost of nuclear propulsion, lime-lighted with relentless pressure by Vice Admiral H. G. Rickover, seem to have made a deep impression on leaders in the Administration and in Congress. Not only was a sistership to *Bainbridge* authorized this year—a year before *Bainbridge* would even put to sea—but Congress was trumpeting the call for a much more vigorous, more ambitious program of nuclear surface ship construction. The general satisfaction on Capitol Hill with Rickover's stewardship and the desire for more of the same is well expressed by three Congressional leaders on as many key committees:

The House's veteran military expert, Rep. Carl Vinson (D-Ga.), chairman since 1931 of the powerful House Committee on Armed Services or its predecessor Naval Affairs Committee, recently told NUCLEONICS, "Beginning next year, all Navy combat ships over 8,000 tons that we build, notwithstanding the higher cost, we should try to build with nuclear propulsion. We think nuclear ships are better; we should build nuclear ships, despite the cost."

The House's principal guardian of military purse-strings, Rep. George Mahon (D-Tex.), chairman of the House Defense Appropriations Subcommittee, says, "I think a majority of us would have preferred to make most or all of these [seven guided-missile destroyers requested in the current budget] nuclear, but we didn't have adequate support from the Defense Dept.* . . . I'm hoping this new Administration, when it has had time to study it, will be inclined to accelerate the nuclear-powered Navy program. I hope that in fiscal-'63 it will adopt a more aggressive policy on nuclear-powered ships."

And former chairman Sen. Clinton P. Anderson (D-N. M.) of the Joint Committee on Atomic Energy stands by his prophecy of two years ago: "I think it is safe to predict that . . . by the end of the 1960's the majority of our combatant ships will be propelled by atomic energy . . . By the beginning of 1970, all of our large military

* Secretary of Defense Gates of the outgoing Administration said Dec. 5, 1960, "The Dept. of Defense does not see its way to approving inclusion of a nuclear-powered frigate in the 1962 Navy budget as proposed by the Navy."

ships—submarines, aircraft carriers, cruisers—will sail the seas under atomic power."

However this does not yet mean that all is an unbroken vista of easy contracts for the nuclear industry. There are still tough economic, strategic and technical blocks to overcome.

Influences on Building Surface Ships

The big push for budgetary acceptance of the nuclear surface combat ship first broke the surface this spring, with introduction into hearings before both the Vinson and the Mahon committees of a Navy study paper entitled "A Treatise on Nuclear Propulsion in Surface Ships."† Its origins lay in an attempt by the Navy's Chief, Admiral Arleigh Burke, to mediate and end a behind-the-scenes running battle in the top echelons of naval command. This pitted Rickover progressives, anxious to move at once into a large-scale program of nuclear surface-ship construction, against conservatives contending that nuclear ships are a desirable luxury the Navy can't afford in the light of its needs for at least a minimum number of combat ships to cover specific areas in which the country has strategic or political commitments.

Result of the study was embodied in the treatise, agreed to by both sides at a Pentagon meeting April 5. The treatise is objective to the point of being oracularly ambiguous: it has been used as ammunition by both parties to the divergence of view. Those who see it as essentially cautionary cite its passages that "the increased cost is the governing factor" in determining that only a "moderate" number of nuclear surface ships "can be built under present conditions of cost." On the other hand Rickover hails it because it "confirms" that the cost of nuclear-powered surface ships is about 1½ times that of conventional surface ships having comparable military characteristics. The treatise explains that:

> When the inclusion of nuclear-propelled surface ships in the shipbuilding programs is being considered, the increased cost is the governing factor. The current [Jan. 1, 1961] progress of the nuclear propulsion program . . . has provided sufficient information to permit a usable estimate of the relative costs of the four principal elements involved, i.e., initial construction, personnel requirements, fuel consumption and upkeep, maintenance and overhaul . . . prepared for a 20-year life of ship and have included estimates for the amortization of the cost of delivering and storing Navy standard fuel oil in the deployed areas. These studies indicate that the current classes of nuclear-powered ships will cost about 1.5 times, or slightly less, as much as their conventionally-powered counterparts. These are 'dollar comparisons' and do not reflect the fact that the endurance of nuclear-powered ships is many times that of the conventionally-powered ships. The figure for submarines is of a similar order, but the comparison is less valid since the nuclear submarines have capabilities that the conventional submarines can never attain. The prognosis of developments for reducing these cost ratios is very encouraging . . .
>
> . . . The progress in development of nuclear reactor cores is highly encouraging for the future. The core life has increased several fold from the first *Nautilus* core, and the AEC has indicated that they are working on longer life cores. Further, the costs of these cores are decreasing at the same time core life is being extended . . . "

The treatise discusses briefly the effect of nuclear propulsion in surface ships on weight, space and endurance, on provisions and supplies, on construction and overhaul facilities, on benefits to different types of ships. It enumerates favorable aspects and limiting aspects of nuclear propulsion in surface ships, and concludes:

> The Navy intends to enlarge its future nuclear surface ship program in a manner that is consistent with its other requirements. The Secretary of Defense has expressed support for the Navy's intention to work toward a nuclear-powered Navy. The number of nuclear-powered surface ships that can be built under the present conditions of cost will be moderate. When the developments have progressed further so that these factors are reduced, the rate can be accelerated, for the potential advantages of nuclear propulsion are well recognized.

The Navy's leader during its last six years of unprecedented transformation sees its position this way: "We want to build nuclear-powered ships at an ever-increasing rate, because they're getting better," Adm. Burke told NUCLEONICS in July. "But we can't afford to jump overboard. We just have to take it in stages."

Burke, Chief of Naval Operations until his retirement

Nuclear Navy Summary (9/1/61):

SUBMARINES:		
In operation	21	(incl. 6 FBM)
Launched, being fitted out	6	(" 3 ")
Keels laid, under construction	14	(" 5 ")
Assigned to shipyards, to be laid down soon	17	(" 15 ")
Authorized, to be assigned for construction	3	
Total submarines	61	
Total submarine reactors	62*	
SURFACE SHIPS:		
In operation	1	cruiser
About ready for trials	1	carrier
Launched, being fitted out	1	frigate
Authorized, to be assigned for construction	1	frigate
Total ships	4	
Total reactors	14	
LAND-BASED PROTOTYPES:		
Operating—at NRTS, Idaho	3	(STR, 2 A1W)
at West Milton, N. Y.	1	(S3G)†
at Windsor, Conn	1	(S1C)
Under construction—		
at NRTS, Idaho	1	(S5G [NCR])
at West Milton, N. Y.	1	(D1G)
Total	7	
TOTAL NAVAL REACTORS	83‡	

* including 2 aboard *Triton*, but not including *Seawolf's* first, S2G, reactor—removed.
† not including *Seawolf* prototype S1G—dismantled.
‡ not including S1G, S2G.

† Reprinted in Hearings before Committee on Armed Services, House of Representatives, on Authorizing Appropriations, April–May 1961, pp 1466–1471.

1961 Progress Report on the Nuclear Navy

Ship-bldg. Program Year	Ship No.	Ship Name	Shipyard	Reactor Type	Reactor Prime Contract	Dimensions Displ. tons—Length—Beam	Date (*Future target dates in italics*) Keel Laid	Launch	Start Sea Trials	Commiss'g.	Cost $10⁶
1952	SSN 571	NAUTILUS	Electric Boat	S2W	W	3,180 — 320 — 28	6-14-52	1-21-54	1-17-55	9-30-54	90
1953	SSN 575	SEAWOLF	Electric Boat	S2G S2W-A	GE W	3,260 — 330 — 30	9-15-53	7-21-55	1-21-57 8-28-60	3-30-57 9-30-60	94 +20
1955	SSN 578	SKATE	Electric Boat	S3W	W	2,360 — 268 — 25	7-21-55	5-16-57	10-27-57	12-23-57	50
1955	SSN 579	SWORDFISH	Portsmouth	S4W	W	2,360 — 268 — 25	1-25-56	8-27-57	8- 9-58	9-15-58	50
1956	SSN 583	SARGO	Mare I.	S3W	W	2,360 — 268 — 25	2-21-56	10-10-57	8- 3-58	10- 1-58	45
1956	SSN 584	SEADRAGON	Portsmouth	S4W	W	2,360 — 268 — 25	6-20-56	8-16-58	10- 5-59	12- 5-59	45
1956	SSN 585	SKIPJACK	Electric Boat	S5W	W	2,830 — 252 — 29	5-29-56	5-26-58	3- 8-59	4-15-59	65
1956	SSRN 586	TRITON	Electric Boat	S4G	GE	5,900 — 447 — 37	5-29-56	8-19-58	9-27-59	11-10-59	104
1956	SSGN 587	HALIBUT	Mare I.	S3W	W	3,555 — 350 — 29	4-11-57	1- 9-59	9-13-59	1- 4-60	65
1957	SSN 588	SCAMP	Mare I.	S5W	W	2,830 — 252 — 29	1-23-59	10- 8-60	4-10-61	6- 5-61	50
1957	SSN 589	SCORPION	Electric Boat	S5W	W	2,830 — 252 — 29	8-20-58	12-19-59	6-27-60	7-29-60	50
1957	SSN 590	SCULPIN	Ingalls	S5W	W	2,830 — 252 — 58	2- 3-58	3-31-60	3-28-61	6- 1-61	50
1957	SSN 591	SHARK	Newport News	S5W	W	2,830 — 252 — 29	2-24-58	3-16-60	1- 6-61	2- 9-61	50
1957	SSN 592	SNOOK	Ingalls	S5W	W	2,830 — 252 — 29	4- 7-58	10-31-60		*10- 2-61*	50
1957	SSN 593	THRESHER	Portsmouth	S5W	W	3,747 — 279 — 31	5-28-58	7- 9-60	4-30-61	8- 3-61	60
1958	SSN 594	PERMIT	Mare I.	S5W	W	3,747 — 279 — 31	7-16-59	7- 1-61		*4- 1-62*	50
1958	SSN 595	PLUNGER	Mare I.	S5W	W	3,747 — 279 — 31	3- 2-60	*12- 9-61*		*9-62*	50
1958	SSN 596	BARB	Ingalls	S5W	W	3,747 — 279 — 31	11- 9-59	*1- 6-62*		*11-62*	50
1958	SSN 597	TULLIBEE	Electric Boat	S2C	CE	2,175 — 260 — 29	5-26-58	4-27-60	10- 2-60	11- 9-60	75
1958	SSBN 598	GEORGE WASHINGTON	Electric Boat	S5W	W	5,600 — 380 — 33	11- 1-57	6- 9-59	11-15-59	12-30-59	110
1958 sup	SSBN 599	PATRICK HENRY	Electric Boat	S5W	W	5,600 — 380 — 33	5-27-58	9-22-59	3- 7-60	4- 9-60	90
1958 sup	SSBN 600	THEODORE ROOSEVELT	Mare I.	S5W	W	5,600 — 380 — 33	5-20-58	10- 3-59	12-12-60	2-13-61	90
1959	SSBN 601	ROBERT E. LEE	Newport News	S5W	W	5,600 — 380 — 33	8-25-58	12-18-59	9-31-60	7-16-60	100
1959	SSBN 602	ABRAHAM LINCOLN	Portsmouth	S5W	W	5,600 — 380 — 33	11- 1-58	5-14-60	1-31-61	3-11-61	100
1959	SSN 603	POLLACK	N. Y. Shipbldg.	S5W	W	3,747 — 279 — 31	3-14-60	*1-20-62*		*12-62*	50
1959	SSN 604	HADDO	N. Y. Shipbldg.	S5W	W	3,747 — 279 — 31	9- 9-60	*8-15-62*		*5-63*	50
1959	SSN 605	JACK	Portsmouth	S5W	W	3,747 — 279 — 31	9-16-60	*8-18-62*		*3-63*	50
1959	SSN 606	TINOSA	Portsmouth	S5W	W	3,747 — 279 — 31	11-24-59	8-26-61		*6-15-62*	50
1959	SSN 607	DACE	Ingalls	S5W	W	3,747 — 279 — 31	6- 6-60	*3-17-62*		*3-63*	50
1959	SSBN 608	ETHAN ALLEN	Electric Boat	S5W	W	6,900 — 410 — 33	9-14-59	11-22-60	6-18-61	8- 8-61	105
1959	SSBN 609	SAM HOUSTON	Newport News	S5W	W	6,900 — 410 — 33	12-28-59	2- 2-61		*1-26-62*	105
1959	SSBN 610	THOMAS A. EDISON	Electric Boat	S5W	W	6,900 — 410 — 33	3-15-60	6-15-61		*3-24-62*	105
1959	SSBN 611	JOHN MARSHALL	Newport News	S5W	W	6,900 — 410 — 33	4- 4-60	7-15-61		*5-24-62*	105
1960	SSN 612	GUARDFISH	N. Y. Shipbldg.	S5W	W	3,747 — 279 — 31	2-13-61	*1-15-63*		*12-63*	49
1960	SSN 613	FLASHER	Electric Boat	S5W	W	3,747 — 279 — 31	4-14-61	*12- 1-62*		*10-63*	49
1960	SSN 614	GREENLING	Electric Boat	S5W	W	3,747 — 279 — 31	8-15-61	*4- 1-63*		*2-64*	49
1960	SSN 615	GATO	Electric Boat	S5W	W	3,747 — 279 — 31	*12-15-61*	*8- 1-63*		*6-64*	49
1961	SSBN 616	LAFAYETTE	Electric Boat	S5W	W	7,000 — 425 — 33	1-17-61	*6-15-62*		*4-63*	109.5
1961	SSBN 617	ALEXANDER HAMILTON	Electric Boat	S5W	W	7,000 — 425 — 33	6-26-61	*10-15-62*		*6-63*	109.5
1961	SSBN 618	THOMAS JEFFERSON	Newport News	S5W	W	6,900 — 410 — 33	2- 3-61	*2-16-62*		*2-63*	105
1961	SSBN 619	ANDREW JACKSON	Mare I.	S5W	W	7,000 — 425 — 33	4-26-61	*9-15-62*		*7-63*	109.5
1961	SSBN 620	JOHN ADAMS	Portsmouth	S5W	W	7,000 — 425 — 33	2- 6-61	*2-16-63*		*8-63*	109.5
1961	SSN 621	HADDOCK	Ingalls	S5W	GE	3,747 — 279 — 31	4-24-61	*4- 6-63*		*3-64*	49
1961	SSBN 622	JAMES MONROE	Newport News	S5W	W	7,000 — 425 — 33	7-16-61	*8-31-62*		*9-63*	109.5
1961	SSBN 623	NATHAN HALE	Electric Boat	S5W	W	7,000 — 425 — 33	*10-61*	*1- 1-63*		*10-63*	109.5
1961	SSBN 624	Unnamed	Mare I.	S5W	W	7,000 — 425 — 33	*10-61*	*2-15-63*		*11-63*	109.5
1961	SSBN 625	"	Newport News	S5W	W	7,000 — 425 — 33	*10-61*	*11-30-62*		*12-63*	109.5
1961	SSBN 626	"	Electric Boat	S5W	W	7,000 — 425 — 33	*12-61*	*4- 1-63*		*1-64*	109.5
1962	SSBN 627	Unnamed	Newport News	S5W	W	7,000 — 425 — 33					
1962	SSBN 628	"	Electric Boat	S5W	W	7,000 — 425 — 33					
1962	SSBN 629	"	Mare I.	S5W	W	7,000 — 425 — 33					
1962	SSBN 630	"	Newport News	S5W	W	7,000 — 425 — 33					
1962	SSBN 631	"	Electric Boat	S5W	W	7,000 — 425 — 33					
1962	SSBN 632	"	Newport News	S5W	GE	7,000 — 425 — 33					
1962	SSBN 633	"	Electric Boat	S5W	GE	7,000 — 425 — 33					
1962	SSBN 634	"	Mare I.	S5W	GE	7,000 — 425 — 33					
1962	SSBN 635	"	Newport News	S5W	GE	7,000 — 425 — 33					
1962	SSBN 636	"	Portsmouth	S5W	GE	7,000 — 425 — 33					
1962	SSN 637	"	Unassigned	S5W		3,747 — 279 — 31					
1962	SSN 638	"	"	S5W		3,747 — 279 — 31					
1962	SSN 639	"	"	S5W		3,747 — 279 — 31					
1957	CGN 9	LONG BEACH	Beth. Quincy	C1W	W	14,000 — 721 — 70	12- 2-57	7-14-59	7- 5-61	*9- 9-61*	320
1958	CVAN 65	ENTERPRISE	Newport News	A2W	W	86,500 —1,102 — 133	2- 4-58	9-25-60		*11-12-61*	450
1959	DLGN 25	BAINBRIDGE	Beth. Quincy	D2G	GE	7,900 — 564 — 56	5-15-59	4-15-61		*summer '62*	148
1962	DLGN-?	Unnamed	Unassigned	D2G	GE	7,900 — 564 — 56					112

and on its Suppliers

NOTE: Data on components for submarines since the 1957 shipbuilding program are correct as regards number of items ordered from each supplier, but are subject to changes in ship-assignment with variations in construction schedules.

Core	Press. Vessel	Steam Gen.	Pressurizer	Main Coolant: Pumps	Main Coolant: Stop Valves	Main Coolant: Check Valves	Rod drive Mechanisms	Reactor Rod Controls	Reactor Instrumentation	Primary Plant Instrum.	Steam Gen. Control	Turbine
W	B & W	2 FW	B & W	W	Chapman	Atw'd-Morrill	W	W	W	W	Bailey	W
GE	CE	2 B & W	none	GE	Crane	GE	Ford Instrum.	GE	GE	GE	Bailey	GE
B&W	B & W	2 FW	FW		Crane	W		W	W	W	W	
W	W	2 W	CE	W	W	Atw'd-Morrill	Bendix	W	W	W	Swartwout	W
W	W	2 W	CE	W	W	Atw'd-Morrill	Bendix	W	W	W	Vickers	W
B&W	B & W	2 CE	CE	W	Crane	Atw'd-Morrill	Bendix	W	W	W	Vickers	W
W	B & W	2 W	CE	W	Crane	Atw'd-Morrill	Bendix	W	W	W	W	W
W	B & W	2 B & W	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	W	W	W	W
2 M&C	2 CE	4 CE	2 B & W	W	Crane	Walworth	Marvel-Schebler	GE	Dumont	GE	GE	GE
W	B & W	2 W	CE	W	Crane	Atw'd-Morrill	Bendix	W	W	W	W	W
W	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	W	W	W	GE
W	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Aerojet-General	W	W	W	GE
CE	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Aerojet-General	W	W	W	GE
M&C	B & W	2 CE	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Aerojet-General	W	W	W	GE
OM	B & W	2 CE	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Aerojet-General	W	W	W	GE
CE	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Aerojet-General	W	W	W	GE
W	B & W	2 CE	FW	W	Crane	Atw'd-Morrill	Thompson	Aerojet-General	Daystrom	Consol.	W	W
OM	CE	2 CE	FW	W	Crane	Atw'd-Morrill	Thompson	W	Daystrom	Consol.	W	W
OM	B & W	2 CE	CE	W	Crane	Atw'd-Morrill	Thompson	W	Daystrom	Consol.	W	W
CE	CE	2 CE	Alco	W	Crane	Atw'd-Morrill	Marvel-Schebler	GE	W	W	W	W
M&C	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	Daystrom	W	Vickers	GE
CE	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	Daystrom	W	Vickers	GE
M&C	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	Daystrom	W	W	GE
M&C	B & W	2 FW	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	Daystrom	W	W	GE
B&W	B & W	2 CE	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	Daystrom	W	W	GE
B&W	B & W	2 B & W	CE	W	Crane	Atw'd-Morrill	Thompson	W	W	Consol.	W	GE
B&W	CE	2 B & W	FW	W	Crane	Atw'd-Morrill	Vard	W	W	Consol.	W	GE
B&W	B & W	2 B & W	Alco	W	Crane	Atw'd-Morrill	Vard	W	W	Consol.	W	GE
OM	CE	2 B & W	CE	W	Darling	Atw'd-Morrill	Marvel-Schebler	W	W	W	W	DeLaval
OM	CE	2 B & W	Alco	W	Crane	Atw'd-Morrill	Marvel-Schebler	Consol.	W	W	W	W
OM	B & W	2 B & W	FW	W	Crane	Atw'd-Morrill	Marvel-Schebler	Consol.	W	Vickers	W	GE
OM	B & W	2 B & W	CE	GE	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	W	Vickers	W	W
B&W	B & W	2 B & W	CE	GE	Crane	Atw'd-Morrill	Marvel-Schebler	Curtiss-Wright	W	W	W	GE
B&W	B & W	2 B & W	CE	GE	Crane	Atw'd-Morrill	Marvel-Schebler	W	W	W	W	W
	A. O. Smith	2 B & W	FW		Crane	Atw'd-Morrill	Marvel-Schebler					
OM	B & W	2 B & W	FW		Crane	Atw'd-Morrill	Marvel-Schebler					
	CE	2 FW	FW		Crane	Atw'd-Morrill						
	CE	2 A. O. Smith	FW		Crane	Atw'd-Morrill						
B&W	B&W	2 FW	Alco	W	Crane	Atw'd-Morrill	Marvel-Schebler	W	W		W	GE
B&W	CE	2 FW	Alco	W	Crane	Atw'd-Morrill	Marvel-Schebler	W	Consol.		W	GE
M&C	CE	2 B&W	Alco	W	W	Atw'd-Morrill	Marvel-Schebler	W	Consol.		W	W
M&C	CE	2 B & W	Alco	W	W	Atw'd-Morrill	Bendix	W	W		W	W
M&C	B & W	2 B & W	Alco	W	W	Atw'd-Morrill		W	W		Vickers	DeLaval
	B & W	2 FW	FW		W	Atw'd-Morrill						
OM	B & W	2 FW	Alco		W	Atw'd-Morrill						
OM	B & W	2 FW	Alco		W	Atw'd-Morrill						
OM	B & W	2 FW	Alco		Crane	Atw'd-Morrill						
OM	B & W	2 FW	FW		Crane	Atw'd-Morrill						
OM	B & W	2 FW	FW		Crane	Atw'd-Morrill						
2 W	2 CE	8 FW	2 Alco	GE	Crane, Chapman	Hammel-Dahl	Bendix	Ward-Leonard	W	W	GE	2 GE
4 OM, 2 W, 2 M&C	2 FW, 6 CE	16 W, 16 FW	4 FW, 4 Alco	16 GE 16 W	32 Crane, 32 W	32 Atwood-Morrill	United Shoe, Vard	W	W	Vickers	GE	8 W
2 OM	2 CE	6 FW	2 Alco	W	Crane	Atw'd-Morrill	United Shoe	GE	Bendix	Consol., W	W	2 GE

No data yet on contract awards for ships being funded by Congress this summer

No data yet

Navy reactor designations have one letter indicating type of vessel (S = submarine, A = aircraft carrier, C = cruiser, D = destroyer-leader [frigate]), one number indicating the order of construction of the reactor type, and one letter for the manufacturer's initial (W = Westinghouse, G = General Electric, C = Combustion Engineering). **Ship designations** are: SSN = Submarine, nuclear [attack type], SSRN = Submarine, radar-picket, nuclear; SSGN = Submarine, guided-missile, nuclear; SSBN = Submarine, ballistic-missile, nuclear; CGN = Cruiser, guided-missile, nuclear; CVAN = Aircraft Carrier, attack, nuclear; DLGN = Destroyer leader, guided-missile, nuclear

Company abbreviations:
B&W = Babcock & Wilcox
CE = Combustion Engineering
FW = Foster Wheeler
GE = General Electric
M&C = Metals & Controls
OM = Olin Mathieson (now United Nuclear)
W = Westinghouse
Consol. = Consolidated Control Corp.

Aug. 1, was replying to a NUCLEONICS question about the Navy's real attitude on the treatise's two-for-three formula, and about opposite interpretations placed on Navy testimony before Congress about it (i.e., some observers see it as meaning the Navy feels it cannot afford nuclear ships until the cost difference has declined all the way to equivalence; others read it as a tacit invitation for bigger appropriations to permit construction of more big combatant ships with nuclear powerplants.)

"The truth is some place in between there," Burke says. "The faster we can get into nuclear power, the better off we'll be—and the faster it will improve. There are only two causes for hesitation: it costs more, and it weighs more.

"We are in the beginning of the era of nuclear power. In ten years we're going to have much better plants, big improvements in the core, in size [reduction], some improvement in weight, in cost. So if we now buy all our ships of the first [nuclear] model, we've got to live with them for a long time, because a ship lasts 20 years."

Burke also points out that we need more ships than we are getting now, and that even if we did get more money, we'd still have to spend some of it on nuclear ships and some on additional conventional ships. "It's no good having the best ship in the world that can do everything including cook," Burke says, "if you have it in the North Atlantic and you need it in the Pacific."

Complications

The Navy's problem is a harsh one. For another aspect of the minimum-ships-required dilemma concerns replacement of over-age ships. The Navy now operates 817 ships, most of them built in World War II and now on the thin edge of obsolescence. Since World War II we have been building an average of 22 new ships a year: thus, by simple arithmetic, by 1970 we would be down to 440 serviceable ships, of postwar construction, the rest having been worn out after 20 years' service. If we had been building 40 ships a year for the last ten years, we would be maintaining present fleet size; now, to catch up by 1970, we would have to build about 60 ships a year.

On the other hand Adm. Rickover contends that, since most of the 817 ships are naval auxiliaries, not fighting ships, it is only a matter of some 70–80 combat units until 1970 for which nuclear power would enter into question. And he points out that in any age the newer if more expensive ship can do more than the old-fashioned type—or, as he puts it in his sardonic way, "If the most important thing is to have 817, and if nuclear power reduces that number, you can resolve the problem in one of two ways: you can appropriate more money, or you can provide that we have sailing ships."

Rickover also points out that an oil-burning destroyer-leader has a range of only 3,000 miles at flank speed (30–35 knots)—3½ days' steaming—or 8,000 at reduced, cruising speed of 20 knots, whereas *Bainbridge* can go 150–180,000 miles continuously at full power without refueling, or 400–450,000 miles at 20 knots. In practice the conventional destroyer gets its tanks topped off every day so as not to risk getting caught short with fuel running low ("those damn ships are always running around with a hose in their mouth," complains one ship-operating admiral). Yet one cannot dispense with fleet tankers and oilers with only one or two nuclear ships—it's not until an entire task force has been converted to nuclear power that one can begin to get rid of the fuel supply train.

Nevertheless, Secretary of the Navy John B. Connally asked the question in April, "In the era of multiple trouble spots and limited wars, would not two nuclear-powered frigates be worth three ships that are tied to oilers and preoccupied with fuel conservation? We need to think big and well into the future. Past experience is a good base, but it should not limit us."

The present balance-point of all these arguments—the market that the nuclear industry has to look forward to—seems to be that the Navy will now request each year a small but growing number of nuclear surface ships—probably mostly destroyer-leader types—in the next 2–4 years, before facing up to the decision (reached for submarines in 1956) to build no more oil-burning combat surface ships at all. The fundamental problem is essentially budgetary, and the big upswing to large-scale nuclear ship construction could come even earlier—or later—depending on fluctuations in the rate of nuclear power cost reduction and of total defense spending; Congress meanwhile can be expected to exert constant pressure for moving ever faster into ever-larger nuclear shipbuilding programs. As Burke puts it, "We plan to build nuclear-powered surface ships every year, and increase their number as fast as we can reduce the cost per horsepower. If we make big improvements in the cost/hp, we will build more; if we make no improvement in the cost/hp, we will build fewer." One 10-year building-program study would have us by 1972 with 6–7 nuclear cruisers, 5 carriers, a larger number of destroyer leaders. For the Administration, Secretary Connally is making a thorough personal review of the shipbuilding program with a view to getting the most h.p/dollar and will shortly announce his findings—which could constitute a new Navy policy and new ground rules on use of nuclear propulsion.

The Technical Problem: D1W

Aside from the fundamental budgetary and global-strategic considerations, there is a knotty technical problem in extending nuclear power to general fleet use. That is development of a single reactor powerful enough and compact enough to power a destroyer (*Bainbridge* and her FY-'62 sister use twin D2G reactors).

The D1W project, only new naval-reactor development program to have been started in the last two years, is being pursued at the Naval Reactors Branch's Westinghouse-operated Bettis Laboratory. (Newport News Shipbuilding & Drydock Co. is working on hull configuration and machinery arrangement.) Aim is to produce a reactor that would have twice the power of a D2G reactor (i.e., an output equal to that of *Bainbridge's* twin-reactor plant) with a volume about the same as that of one D2G. "This will be a difficult development," comments Adm. Rickover, "because it will be the highest power reactor that we will have so far developed for naval propulsion. . . . It will have . . . more than 1½ times the capacity of the present largest naval reactor." This comparison with the A1W-A2W indicates the D1W would make about 60,000 shp. (A modern conventional guided-missile destroyer today averages 80–85,000 shp, meaning it would be somewhat faster than a D1W-propelled sister.) D1W will take about four years to develop, Rickover said; it would thus

be ready for use about 1964–65.

The problem of D1W application seems to be that weight-reduction might be only about 20%—from about 3,000 tons for a pair of D2Gs to about 2,500 tons. Thus it could bring the tonnage of the smallest ship that can use nuclear power down from *Bainbridge's* 7,600 tons by only about 1,000 tons—it would still not be applicable to the 1,800–2,600-ton destroyer-escorts. Against this, Rickover argues that, more and more, the size of a ship is no longer determined by its propulsion plant but by its military characteristics: "the space required by the military items is now becoming the governing feature"; thus, he says, "the 8,000-ton nuclear frigate is [only] about 100 to 300 tons heavier than a conventional frigate having the same military characteristics. The trend is for this difference in displacement to go down."

Surface Ship Experience Slight but Good

The very brief experience at sea to date of the U. S.' only completed nuclear surface ship certainly augurs well for the long line of nuclear ships that will follow her.

Long Beach has been at sea only about five days as this is written—on her three-day maiden trial cruise starting July 5, and again for two days a fortnight later. Yet in this brief time she has proved "far more promising than we had anticipated," exceeding her design speed (believed to be about 30–31 knots), power output, and maneuvering requirements. Adm. Rickover says *Long Beach* "will have as great an effect on surface navies as *Nautilus* had on undersea navies." The first time she opened up her reactors under way—less than two hours after leaving dock for the first time—she demonstrated one marked advantage of nuclear propulsion: fast acceleration. Because a reactor can deliver a full head of steam on demand far more promptly than an oil-fired boiler, she was able, after traversing Boston harbor at dead-slow (accompanied by NUCLEONICS' launch), to step out for the Atlantic with a dazzling burst of speed.

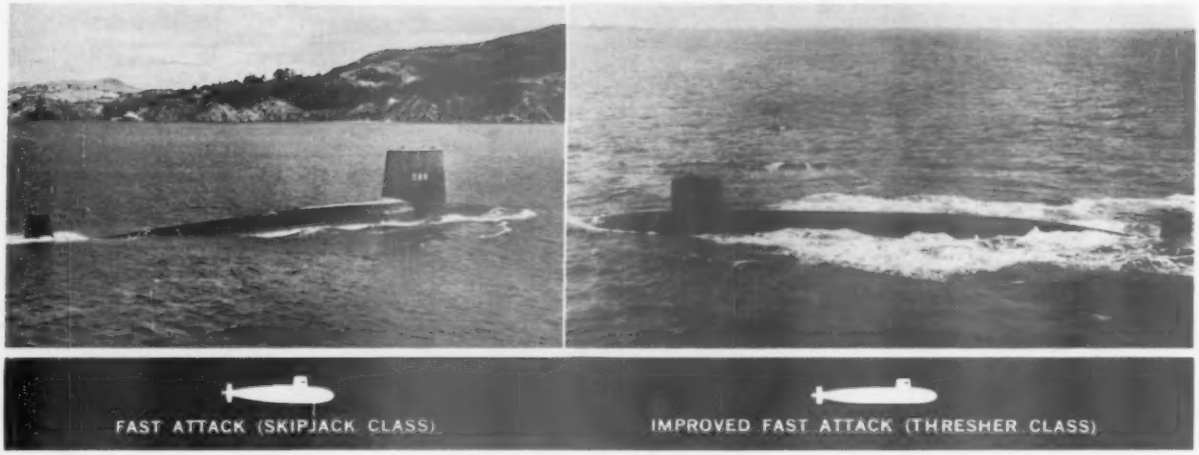
The cruiser's mounting cost has been a subject of questions in Congress. In 1957, estimated cost was $84,641,000; currently estimated final cost is $320,547,000. "There are a lot of reasons why the *Long Beach* cost increased," Adm. Burke explains. "One was a lengthy strike, which cost us not only time but a lot of money. Another reason was that we put a lot of new equipment in . . . we put everything new in that ship that was developed"—Talos missiles, the powerful SPS-32 and SPS-33 radars, the new naval tactical data system, Polaris capability (*Long Beach* is described as the Navy's most complicated ship). Meanwhile, as Adm. Rickover points out with pride, the cost for the 80,000 shp nuclear plant was $41-million in 1957, and is still $41-million today. *Long Beach* will be commissioned Sept. 9 and will then proceed to Norfolk as its operating base.

Enterprise, biggest ship in history and biggest moving thing man has ever made, with her 4½-acre flight deck and complement of 4,600 men, will surely seize the world's attention when she moves to sea for the first time, in 2–3 months, on the 280,000 horsepower of her eight reactors. Each of the eight has gone critical and been tested at dockside at full power. *Enterprise,* Rickover says, will be able to cruise over 140,000 miles at full power (as compared with less than 4,000 for a conventional carrier) and over 400,000 miles at 20 knots (about 8,000 for the oil-burner). One of the most fantastic records already chalked up by this mammoth ship is that despite the unprecedented job of building, installing and completing eight power reactors, she was built in four years, on schedule—two years faster than *Kitty Hawk* and a year faster than *Constellation,* both conventional and slightly smaller carriers—thanks to the joint efforts of Newport News Shipbuilding, Westinghouse, and Naval Reactors Branch.

Her power plant cost about $165-million of the ship's total cost of $450-million. Her electronic equipment alone cost more than an entire *Essex*-class carrier. The eight reactors are arranged as four powerplants (two reactors per propeller shaft), with each plant having its own control room, called PPEOS—"primary plant enclosed operating station"—but with one of the four being the responsibility-carrying master station that acknowledges maneuvering and power-demand orders from a main engineering Control Center or direct from the ship's bridge. Staff organization is the same as on a conventional Navy ship (again pointing up how commonplace reactors have become): an Engineering department (800 men on *Enterprise*) divided into divisions: E (electrical), M (Main propulsion), A (Auxiliaries), R (Repair), with only the B (Boiler) division replaced by an RC (Reactor Control) division. On *Enterprise* the RC division has two officers, 75 men ("the same as a boiler division—we wouldn't dare use more men than a conventional ship or we'd be criticized"). In addition to eight 2500-kw turbogenerators for ship's service power, *Enterprise* has eight more, also 2500-kw, just for main primary coolant pump service alone: one per reactor (each reactor has four 800-kw pumps, but only three operate at a time). *Enterprise's* home port has not yet been announced, but Norfolk would be a good guess—notwithstanding a fanciful report that *Enterprise* will be a modern-day Flying Dutchman, doomed by AEC safety requirements to stay out of "major harbors" and anchor "well off shore." Actually *Nautilus* has operated twice in New York City, *Long Beach* in Boston, subs for years in New London, Norfolk, San Francisco, the Panama Canal, etc., without arousing public anxiety.

If a second nuclear aircraft carrier should be proposed again—as it was, vainly, in 1959—it would have only four reactors instead of eight, the Navy says. Each one would probably be of D1W size for a total of 240,000 shp (only about 14% less than *Enterprise,* resulting in only about one knot less in maximum speed). But two years ago the cost difference between the conventional carrier that was finally voted and the nuclear that was defeated was $130-million. Today, says Adm. Rickover, "the total difference between nuclear and conventional carriers with the same military characteristics is about $93-million . . . of this, $30-million is nuclear fuel."

Bainbridge is becoming this summer the world's first nuclear surface ship to get a sistership, with authorization by Congress of a second nuclear destroyer-leader. Launched April 15, *Bainbridge* is now fitting out and is to



FAST ATTACK (SKIPJACK CLASS)

IMPROVED FAST ATTACK (THRESHER CLASS)

be ready for sea in late summer or fall of 1962. Her original cost estimate of $105-million has risen to $150-million. In the same period, however, Rickover told Congress, the cost estimate of the nuclear plant went down from $38.7-million to $33.7-million, enabling him to return $5-million to the Treasury. With the economies that can be made in building a follow ship as against a lead ship, the one authorized this year is budgeted for only $112-million. The incremental cost of the nuclear vessel over the conventional is now $35-million, Rickover says, but of that, $8-million is for the two cores.

Bainbridge will have 170 in her Engineering department, 20 in the RC division. Her nuclear instrumentation is completely transistorized.

The D1G prototype at West Milton, N. Y., was to have gone critical in July, but isn't likely to make it until October at least; fuel fabrication problems are believed to be involved, at Olin Mathieson (now United Nuclear).

Submarines Continue to Revolutionize Navy

One-of-a-kind subs—the two prototypes *Nautilus* and *Seawolf* and the three special-purpose craft *Halibut*, *Triton* and *Tullibee*—have all been operational for some time now. *Nautilus* spent 14½ months (May 28, 1959–Aug. 15, 1960) at Portsmouth Naval Shipyard for her second refueling, and first regular overhaul after 153,886 miles steamed. The overhaul was to have taken nine months or less, but was delayed by a variety of problems—from the fact it was Portsmouth's first nuclear overhaul, to a shortage of skilled labor and a crude case of attempted sabotage. It has been said that when her primary plant components—pumps, valves, etc.—were opened up, they looked as if they were fresh from the factory, so little evidence of wear was there. *Nautilus* is back in operation with the fleet, as is *Seawolf* after her conversion from a sodium-cooled reactor to a pressurized-water unit.

Of the three special-purpose submarines, two have already been reclassified and lost their special assignment, and the third may follow suit. *Tullibee* was first to be redesignated from SSKN (nuclear hunter-killer sub) to SSN (nuclear attack sub) when it was decided that the hunter-killer and attack functions are not different enough to justify a distinction: i e., that an anti-surface-ship (attack) sub needs the same capabilities as an anti-sub (hunter-killer) sub. *Triton*, the globe-girdling two-reactor sub, still world's biggest (although she will lose that distinction to the *Lafayette*-class third-generation Polaris sub), was next, losing the SSRN (radar-picket) tag early this year. The radar-picket function in the fleet was a World War II anti-kamikaze defense function when radar ranges were limited; with the improvement in radar ranges since then, the function has become obsolete. *Triton* still serves not only as a powerful attack sub, but also as a potential study vehicle for possible larger subs, perhaps cargo or troop-transport types, in future. *Halibut*, first of what was to be a class of SSGN (guided-missile-firing) subs, is the only nuclear-propelled sub left in the canceled Regulus missile program; she now exerts "her own brand of deterrence" with her Regulus missiles, shorter-ranged than Polaris; but Regulus will eventually be phased out, and *Halibut* will then be reconverted to some other use, not yet decided. With her huge missile hangars, troop transporting, cargo carrying, or some special application of anti-submarine warfare are possibilities.

Tullibee is pioneering the latest in sonar techniques—both in active and passive sonar listening equipment, and in silencing of her own sources of noise. Result is that she has capabilities of detecting other subs while remaining undetected herself that are orders of magnitude beyond anything previously dreamed possible. Silencing of her self-generated noise also contributes to her hearing better. *Tullibee* can hear—and identify—a wrench dropped on the floor, a man going through a door, even spoken commands, in another sub at a distance of "several miles," while undetected. An experiment in noise suppression is *Tullibee*'s turbo-electric drive, eliminating reduction gears; this also adds greatly to her maneuverability. But her most striking feature is the $6-million worth of the most advanced sonar equipment (she has more sonar transducers and hydrophones aboard than all U. S. subs in World War II). She is also the world's first submarine to have her torpedo tubes amidships, angled outward, to leave the bow free

POLARIS I (GEORGE WASHINGTON CLASS)

POLARIS II (ETHAN ALLEN CLASS)

for a hydrophone-packed 12.5-ft dia, 70-ton sonar sphere.

Fleet type subs are now operating routinely. Three (*Skate, Sargo, Seadragon*) have been to the North Pole; three (*Sargo, Swordfish, Seadragon*) are now assigned to the Pacific Fleet at Pearl Harbor. The U. S. thus now has two subs in each ocean fitted for polar under-ice cruising. Planned for 1962: two nuclear subs will make a polar cruise together (all Arctic operations to date have been solo) to test under-ice communications and multiship operations. *Skate* is just completing her first recharging after setting a record for core longevity: her first core lasted 39 months, drove her 120,862 miles (*Nautilus'* first core life: 26 months, 69,138 miles).

Fast attack type subs now include six first-generation *Skipjack* class and 17 second-generation *Thresher* class units. This type is one of two (along with the Polaris type) on which the Navy has settled—they correspond in function and mission to fighters and bombers in the Air Force; these are the only two types of nuclear subs now being built. *Skipjack*, whose sweeping success was reported here in 1959, has since gained additional luster for her ingenious hull design and her S5W reactor plant, as her sisters followed her to sea. They are rewriting the book on submarine tactics and utilization.

"There is no question but that the nuclear attack subs have proven themselves and now will go on to better things," says Adm. I. J. Galantin, chief of the Navy's undersea warfare section. "We have yet to see the full application of nuclear submarines." Another top operating leader, Adm. Elton W. Grenfell, Commander of Submarines–Atlantic, concurs: "Nuclear power has increased the effectiveness of the submarine service to a degree greater than we can estimate. Its advent is one of the most signal advances in the history of marine engineering, and its gift of great endurance one of the greatest engineering advances, as great as Sputnik."

A *Skipjack*-class sub carries 8 officers, 82 men, of whom 3 and 55 are in the Engineering department (but the 55 includes an allowance for trainees). Also, the department has charge of many non-propulsion items. The propulsion plant itself requires one officer and ten men on duty per watch.

Between her single reactor and single propeller, S5W-equipped subs have almost every electrical and mechanical system installed in duplicate. In addition, every control feature of the powerplant has at least one backup method of operation in addition to the normal one. Startup from a cold condition begins only four hours before underway time with a pre-critical check-off; the in-port watches in the reactor and engine compartments check systems lined up for operation. Two hours before underway, the engineering duty section stations the watch, and pulling of rods begins; 1½ hours before, reactor startup has been completed and primary loop and steam lines are being warmed up. Thirty minutes before underway, the turbines are warmed up and the ship's service turbogenerator sets started. Fifteen minutes before underway, the propulsion plant is "ready to answer bells"—i.e., commands for propulsion power.

Thresher has become more than just an improved *Skipjack*—she and her sisters are the offspring, so to speak, of both *Skipjack* and *Tullibee*. From the former come the streamlined tear-drop (*Albacore*-type) hull shape, with a smaller sail set further forward; the S5W power plant, now a standard, proven quantity; and the fantastic speed and maneuverability that the combination of hull-shape and S5W endow them with. From *Tullibee* come the advances in machinery-silencing and the powerful sonar systems, including the sonar sphere in the bow and the torpedo tubes pushed back amidships. The combination, plus the fact that *Thresher*-class subs are not only faster but can run deeper than *Skipjacks* (*Thresher* set a depth record on her first trial trip) make this class the most prodigious performers and fearsome antagonists on or in any ocean. In addition, *Thresher* ships are fitted to fire the Subroc anti-sub torpedo missile when it becomes operational.

FBM type subs of the Fleet Ballistic Missile (Polaris) program have been so well brought to the public's attention since *George Washington*, first of the type, went to sea Dec. 30, 1959, and demonstrated ability to fire missiles from underwater July 20, 1960, that little need be said to explain the program. Every newspaper-reading American knows that each Polaris sub carries 16 Polaris missiles with nuclear warheads having a total fire power greater than all the bombs dropped by both sides in World War II; that each can stay on patrol submerged for three months; that the first squadron is already operating—two years ahead

of schedule—from a base provided by Britain: an anchorage in Holy Loch off Scotland's Firth of Clyde, where the submarine tender *Proteus*, especially rebuilt for the job, is moored. Today the first generation of five Polaris subs is on patrol or ready to go on patrol, and the first of the second generation, *Ethan Allen*, is going through her shakedown period prior to taking up patrol station. Three more of this group have been launched and are being completed; the fifth and last, *Thomas Jefferson*, will be launched in February. Meanwhile four keels have been laid of a third, even larger class named *Lafayette*, with 15 more authorized.

All 29 have S5W reactors. Differences: the second and third classes have a more streamlined upper body, the first class having been converted, to save time, from the existing *Skipjack* design (in the case of *George Washington*, from an already-started hull). The extra length in the second and third classes has been used primarily to improve livability for the crew, with better berthing and messing arrangements; the difference in *Ethan Allen* over the first five in this regard are said to be enormous. Finally, both advanced classes will be able to fire the A-2 and A-3 Polaris missiles, whereas the *Washington* class, now able to handle only A-1, will be retrofitted for A-2 and A-3. (A-2 has a range of 1,200 nautical [1,380 statute] miles, is now operational; A-2 will have a range of 1,500 [1,725] miles when it becomes operational early in 1962. Eight of ten test flights have been completely, and a ninth partially, successful. A-3 will have a 2,500 [2,875] mile range, bears a target completion date of mid-1964. All three are two-stage, solid-propellant missiles guided by a self-contained inertial system.)

Cost of the Polaris program is estimated at $9-billion (one-quarter for research and development) for a 45-boat fleet, with $1.993-billion appropriated in fiscal-'61; $2.094-billion in fiscal-'62 (including 10 subs at about $100-million each and about 200 missiles at $1-million each); and $2.6-billion estimated in fiscal-'63 (including a sub a month and 200 missiles). From fiscal-1956 through-1961 Congress has appropriated $4.852-billion for Polaris. Total missiles needed with a 45-boat fleet—including 720 in the subs' firing tubes—is set at 1,005, more if number of practice and training firings is increased.

"Performance at sea [of Polaris subs] has met or exceeded our fond expectations," NUCLEONICS was told by Adm. William F. Raborn Jr., the man who in the incredible time of 4½ years converted the Polaris missile system from an idea to an operating reality through a crash program of "scheduled invention." The only major question still open is how many more Polaris subs—beyond the 29 authorized—we need to make sure that none is ever used for its designed purpose.

Whither the A-Sub Program?

Two years ago the Navy's long-term construction goal was to build up to a fleet of about 75 attack subs and 45 Polaris craft by 1970. Are these numbers still valid? "Yes, this is our goal," Adm. Burke told NUCLEONICS a month before his retirement. "We checked it just recently and it still seems to be pretty good."

Rep. Mahon, however, told NUCLEONICS that the rate of building of both attack and Polaris subs is inadequate—and many other Congressional leaders agree with him.

Is the cost of submarine nuclear power coming down to match the surface ship costs cited earlier? Decidedly, would be Adm. Rickover's answer. He told Congress this summer that nuclear plant costs "have been coming down, contrary to the general trend of price increases of about 4–5% a year for nearly all military items." Whereas *Skipjack's* reactor plant cost $18-million, "we are now buying these plants for about $9-million," said Rickover. Likewise, core costs are coming down "considerably" at the same time that core life is going up. Whereas *Nautilus'* first, 69,000-mile core cost $4-million to fabricate, her present third core, good for 140,000 miles, cost about $3-million. Rickover also gave these figures: decrease in cost per operating mile in the last 4–5 years: *Nautilus*-type core, 20%; *Skate*-type core, 65%; *Skipjack*-type core, 65%; increase in core life: *Nautilus* core, 100%; *Skate* core, 20%; *Skipjack* core, 20%. Similarly, surface-ship core costs are down, he said: whereas A1W cores originally cost about $5.5-million, "we are now getting replacement cores for about $2.5-million, yet [these] will have a longer life than the original ones."

Research-development work pursued by Naval Reactors Branch on improved cores is along two lines. One is a step-by-step engineering improvement of the zircaloy-clad metal plate elements believed to be used in all reactors to date (except *Triton's*, which have a twisted-ribbon configuration: NU, Dec. '59, 25). All the previously-cited gains in core life have come as result of such gradual improvement; the means: increased uranium loading per element, as Adm. Ralph K. James, Chief of the Bureau of Ships, told Congress. The other route is development of a radically new, secret ceramic core, thought to be still several years away. Adm. Rickover did not specify which he was talking about when he told Congress in May, "One of the major areas in which we are presently working is to develop nuclear cores which will last much longer. In the manner we are presently running nuclear submarines, these new cores will give us about 8 to 9 years of life. If the nuclear ships were to operate as little as the conventional ones do, we would be getting close to a 20-year life."

NCR. The only new submarine reactor under development is still the Natural Circulation Reactor, now designated S5G; General Electric is the contractor, and the work is done by the GE-operated Knolls Atomic Power Lab. Purpose of NCR is to eliminate primary coolant pumps, second noisiest item in a sub's nuclear propulsion plant (NU, Sept. '59, p. 81). Congress appropriated $18.5-million for the NCR prototype in summer 1959 and NRB then hoped to complete it in 2–2½ years; but an architect-engineer (Giffels & Rossetti, Detroit) was not named until November 1960. Meanwhile the Navy appropriated another $17-million to the project for concurrent development of a direct-drive turbine—also a noise-abatement project; and $3.5-million for machinery to permit the entire prototype reactor to be mounted on gimbals, to reproduce ship's-motion conditions.

Reliability. The most astonishing virtue of the Navy's reactors is not the independence of the surface they confer on subs and the endurance, range and flexibility they give all ships, sub or surface; it is what makes these other qualities truly useful—namely that the independence, endurance, etc., are always available, and can be counted on. The 22 reactors in operation in 21 subs have not had a single breakdown or incident. This is very likely without

parallel in the history of technology for so revolutionarily new an invention. This is not, of course, to say that there have not been occasional failures of equipment or components; but these have involved almost in every case conventional components—pumps, valves, seals, etc.

This reliability is so well built in, moreover, that "maintenance time on the reactor plant is negligible," an engineering officer says. "There practically isn't any. All you do is carry out your checks, button up, and go home."

As far as can be determined, the worst misadventure involving radiation was the incident involving *Theodore Roosevelt* this spring—and as radiation incidents go, most land reactor operators would probably be delighted to be guaranteed that all their incidents would be no more serious than this one. Apparently what happened was that, returning to port after a cruise, *Roosevelt* inadvertently dumped the resins from the ion-exchange demineralizer while the sub was on the surface instead of submerged, and some particles stuck to the deck. "Decontamination" amounted merely to large-scale mopping operations.

The unprecedented, even unheard-of, standards of quality control enforced by Rickover—seen by industry as a cross to be borne but by the operating crews as cause for thanksgiving prayers—are only half the story of the A-subs' reliability record. The other half is the rigorous selection and rigorous training applied to the crews themselves. And here the shoe pinches: the manpower problem is one of the worst the Navy faces. There are more and more A-subs to be manned, and the Polaris subs require two crews each; on the other hand high-I.Q. material is needed and must be trained, in some cases for as long as 42 months—and the Navy's electronics and missile programs are competing for the same men. Here some help may come in time from the SUBIC—Submarine Integrated Control—project working to reduce the number of men required to man a submarine. An early version of one unit in the SUBIC system, a control instrumentation system called CONALOG simplifying steering and diving, has been installed on *Shark*. A push-button control console may be tried out aboard *Tinosa*.

Industry: Competition Stiffer; Need for Spares Rising

On the industrial side, the competitive picture is apparently getting as tight in the primary components fields as it has been in cores (NU, May '60, 20), with Adm. Rickover driving for multiple sources of supply. Biggest change since two years ago is the establishment of MAO—Machinery Apparatus Organization—at GE, paralleling Westinghouse's PAD or Plant Apparatus Division. When the score of prime contracts for ship reactors stood at Westinghouse-46, GE-2, Combustion Engineering-1, the pressure on Rickover to end the appearance of monopoly grew great. With one master-stroke the Admiral reversed the situation: he had GE set up MAO, put it in the business of building Westinghouse-designed S5W reactors, and leaned back to watch the rivals compete to build S5Ws better and cheaper. Profits seem as remote as ever.

Combustion, meanwhile, quietly disappeared from the scene as third prime reactor contractor, with only the smooth-running *Tullibee* testifying to its work.

Among shipyards, Electric Boat and Newport News Shipbuilding have been the backbone of new-construction effort in the past two years, with Ingalls and the two Navy yards, Mare Island and Portsmouth, filling out the picture. Now Adm. Rickover is bringing two more Navy yards into the submarine program: Puget Sound, Bremerton, Wash., and Charleston, S. C. (Charleston already acts as home for the Polaris subs). Several others including Norfolk will be trained to do nuclear repair and maintenance work.

The Spare Parts Market

One source of major expansion in the market for naval reactor components and supplies is the demand for spare parts to fill the shipboard and on-shore supply pipelines for maintenance and repair purposes.

Since a naval vessel must be able to operate independently at sea in any event of an outbreak of local or general hostilities, it must carry all the spare parts it might need at a moment's notice. To predict failure rates and other intangible factors and then decide what parts each different type of ship should carry and in what quantity; to purchase and distribute the items; to keep stocked not only ships' repair-parts bins but also overseas bases, 61 mobile support ships, 15 principal in-port stocking points and 145 additional coastal supply bases; and to keep track of usage and analyze demand—this is the incredibly complex task and responsibility of a little-known Navy Supply Corps organization, the Ships' Parts Control Center, at Mechanicsburg near Harrisburg, Pa.

Before the advent of nuclear propulsion, SPCC had been responsible for supporting hull, deck and engine-room parts, while other parallel organizations of the Navy's Bureau of Supplies and Accounts supported electronic parts, ordnance parts, etc. After *Nautilus* went to sea, another such parallel organization, the Submarine Supply Office, set up a section in September 1956 expressly to support reactor-compartment components. By March 1960 this had become important enough for the Submarine Supply Office to be reorganized as the Submarine and Reactor Parts Supply Office—SUBARPSO for short, and then in April 1961 the new office was melded into SPCC—a minute detail of naval organizational history significant here only because it reflects the fact that reactors are on their way to becoming conventional items in the Navy.

SPCC is a purchasing and planning organization (it stockpiles no hardware) of more than 1,500 Navy Supply Corps officers and civilians. It handles procurement and distribution of 180,000 line items of equipment and parts—from pumps, valves, motors, engines and their parts to nuts and bolts, anchors, oars, rat-guards, shipboard furniture, and—recently added for nuclear ships' health physics labs—filters, rubber gloves, calibrated absorbers, radiac sample holders, shoe covers, silicon grease, etc. Altogether there are over one million ships' repair parts; SPCC directs only 120,000 of them to be stocked, while SPCC or field purchase offices ashore buy the rest as required.

For the FBM program, SPCC has carried out the biggest step forward since the Navy started supplying spare sails: computerization. Previously each ship's parts list ("COSAL" in Navy supply parlance: Co-Ordinated Ship's Allowance List—"co-ordinated" because in an earlier era

there were a dozen separate lists for hull parts, engine parts, ordnance parts, etc.) had been drawn up by Supply Corps technicians making seat-of-the-pants determinations as to the parts that should be carried and the quantity of each. With the advent of the Polaris program, SPCC was asked to develop a more modern system better able to cope with the far more complicated components and equipments aboard these new craft.

The new procedure developed (called "Optimum COSAL") begins with a much more intimate involvement by SPCC with each ship throughout its construction stage and validation by sight appraisal of the resultant Equipment Component List. But its principal feature is that this ECL is then run through an automatic data-processing system (IBM 705). Input factors include "military essentiality" of each item (under which a rating is given each part on a scale ranging from items essential for survival to "happiness items" like ice-cream freezers), cost, weight, cubic volume, demand frequency, and probability of failure. As a consequence of computerization it is now possible, by turning a knob, to get an optimum mix of spare and repair parts for any predetermined cost, or weight, or cubage. For example, one can get a difference of $3-million cost in two 3,000-item lists, depending on how one sets the computer dials. The new system has been working so well it is going to be spread to nuclear attack subs and guided-missile destroyers—eventually to all the rest of the fleet.

Another Nuclear Demand

What the spare-parts requirements will add to the total market for supply of reactor components is not yet entirely clear, in this still-early stage of nuclear-ship operation. (A guess might be anywhere from 25% to 75% for parts subject to wear, but probably below 5% for major primary components such as reactor vessels.) One of SPCC's biggest problems is to get good usage data, as its decisions on what parts to stock and in what quantity are ideally based on experience. When *Nautilus* first went to sea, no one knew to what extent spares were needed for support, and back-up approached 100%. (In fact, *Nautilus'* many dockside-spare primary components became the backbone of the pressurized water reactor later installed in *Seawolf* after her sodium system was abandoned: NU, Sept. '59, p. 77.)

Two factors are tending to reduce a high rate of backup: the growing number of nuclear submarines, and the growing dependability record of their propulsion plants. As the number of units of a given type in service increases, the replacement problem is simplified, and the number of spares stocked is reduced. For example, if there are 10 identical ships in service, SPCC may find it suffices to have components of average dependability backed up 100% for, say, only six ships; if there are 12, it may back up seven; if 15, eight. Likewise, as experience mounts, SPCC learns which parts move faster than others. "Garden variety" material that usually requires replacement (e.g. pump or valve wearing parts) is backed up 100%; material that is slower-moving or that does not require annual replacement (e.g. the entire pump or valve, pressurizer heaters) is backed up 25%; and material that seldom if ever needs replacement but that is crucial to operation or that requires a long lead-time for production (e.g. reactor vessels, pressurizer vessels) is stocked in insurance quantities.

Meanwhile it is already becoming clear that the nuclear propulsion plants—whether because of their intrinsic nature, or the stringency of Adm. Rickover's celebrated quality-control standards, or both—are establishing new levels of reliability. "Whenever someone has a casualty to a primary system, he must report it," says one Navy official; "I have never seen a casualty report on anything affecting a submarine reactor." As NUCLEONICS reported in 1959, most of the failures that *do* occur on nuclear ships affect conventional systems.

Experience does not, however, always work in the direction of reducing the demand for spare parts. Largely because of greater familiarity with the shipboard equipments and their proliferation as new ones are developed, the spare-parts load aboard *Proteus*—the submarine tender for the Polaris subs at their Holy Loch, Scotland, base—grew in one year from the original January, 1960, recommendations, from 1,515 to 3,325 different items, from 11,640 to 25,000 total items, from $900,000 to $1.27-million in value, and from 750 to 2,140 ft^3 volume.

Another factor that tends to increase the size of the spare-parts market is another dimension of necessary duplication: many components are stocked both complete and broken down into their parts (in addition to being stocked on board ship, on the tender, and ashore). For example, nuclear instrumentation—which SPCC supports for every nuclear ship, whether submarine or surface—is supported as entire standard cabinets, as modular drawers, and as transistors, resistors, capacitors, etc.—over 1,000 items of instrumentation alone. Thus, as Adm. Galantin told NUCLEONICS, if something goes sour in a $400 modular drawer and it proves to be a 60¢ transistor, it would obviously be wasteful to junk the drawer or return it Stateside. The ship has a spare drawer ready to pop in place, and it may have—if it doesn't, the tender certainly does—the capability to replace the transistor in the offending drawer, which then can go back into the spare-parts bin.

Although normally remote from the nuclear design function, SPCC can sometimes tell if there is something wrong with an item of equipment just by the frequency of repair calls, and it has consequently more than once been the first to call attention to faulty design. Another way in which SPCC plays a contributory role in submarine engineering is through its value engineering, or "more use for less money," program.

What problems peculiar to the introduction of nuclear energy confront SPCC in its operations? Pretty much the classic ones: special standards of quality control, difficult to meet and occasionally resulting in problems of finding qualified vendors; special materials, and, indirectly, problems related to the requirement of being able to handle radioactive materials (indirectly, because none are handled at Mechanicsburg); the exotic requirement of transparent, dust- and moisture-proof packaging, shock control and humidity control; greater coordination with manufacturers, shipyards, and other organizations concerned because of the number of deviations from routine procedures, etc. But, "by and large, reactor parts have caused a minimum amount of trouble. . . . We experience demand where things wear out or are unreliable; we experience very little demand on reactors in general."

42 Gamma Spectra of Short-Lived Nuclides

by MINORU OKADA, *Government Chemical Industrial Research Institute, Tokyo, Japan*

IF YOU USE NEUTRON ACTIVATION analysis to identify an unknown substance in a specimen, a collection of standard gamma-ray spectra will help determine which nuclide the unknown spectrum from the analyzer represents. Although catalogs of spectra from long-lived nuclides (>5 min) for routine activation analysis have been made in the past (*1, 2*), few have been compiled so far for the hard-to-get short-lived ones (1–100 sec) necessary for rapid activation analysis (*3–7*). The catalog here offers 42 gamma spectra of nuclides with half-lives from 1 sec to 6 min.

How We Collected Spectra

The spectra you see on these pages were gathered by first enclosing a sample in a polyethylene capsule and then irradiating it in the Japan Research Reactor-1 (boiling-water type)—passing it through a pneumatic tube with air pressure ~0.2 kg/cm² (gage).

After the sample had been activated, we measured the gamma-ray spectra with an NaI(Tl) crystal (1¾-in.-diameter 2-in.-thick crystal; ¾-in.-diameter, 1½-in.-deep well) mounted on a Dumont 6292 photomultiplier. This detector was connected in turn to a Radiation Counter Laboratories 256-channel pulse-height analyzer. The resolution of the detector for 0.662-Mev Cs^{137} gammas is ~12%.

Thirty-six of the spectra in the catalog (black backgrounds) were photographed at the Braun-tube monitor in the pulse-height analyzer. The other six (white backgrounds) were recorded with a printer. In this second batch, we used complement-subtraction when activity due to sample holder (filter paper and sometimes polyethylene capsule) was strong enough to interfere.

* * *

The author wishes to express his appreciation to Seishi Yajima for much helpful discussion; Toshio Nakai for permission to use laboratory facilities; Yuichiro Kamemoto, Koreyuki Shida, Muneo Handa and Terutomi Moki for operating the pulse-height analyzer and photographing the gamma-ray spectra; and Fumio Aoki for directing the preparation of the spectra. Special thanks are due Shoji Makishima and Kenjiro Kimura.

BIBLIOGRAPHY

1. L. Salmon, AERE-C/R-2377 (1) (1959)
2. R. L. Heath, IDO-16408 (1957)
3. W. D. Mackintosh, R. E. Jervis, *Anal. Chem.* **30,** 1180 (1958)
4. T. Nakai et al, *Nippon Kagaku Zasshi* **80,** 49 (1959)
5. T. Nakai et al, *Nippon Kagaku Zasshi* **81,** 107 (1960)
6. M. Okada, *Nature* **187,** 57 (1960)
7. M. Okada, *Nature* **188,** 575 (1960)

What Data on Spectra Mean

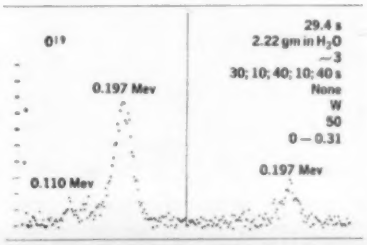
The data for the spectra are listed on the right of each figure according to the following key.

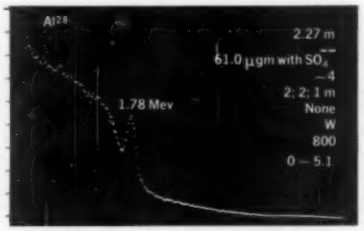
29.4 s	—Half-life
22.2 gm in H_2O	—Material*
~3	—Neutron flux (10^{11} n/cm²/sec)
30; 10; 40; 10; 40 s	—Times†
None	—Aluminum absorber (mgm/cm²)
W	—Counting position‡
50	—Count scale (counts/division)
0–0.31	—Energy range (Mev)

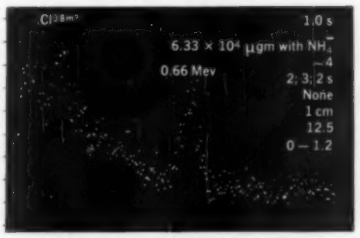
* Number indicates amount of element. Positive or negative chemical notation implies that irradiated material is aqueous solution held by 0.1-gm piece of filter paper.

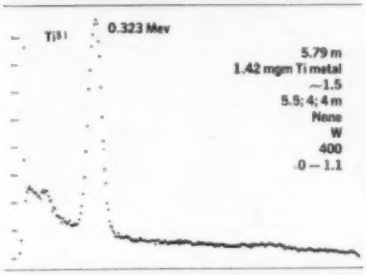
† Shows, respectively, irradiation time, first cooling time, first counting time, second cooling time and second counting time. (Five values occur when 128 channels are used at first counting and remaining channels at second.)

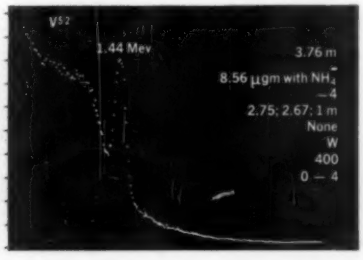
‡ W means "in well." Other distances are above well.

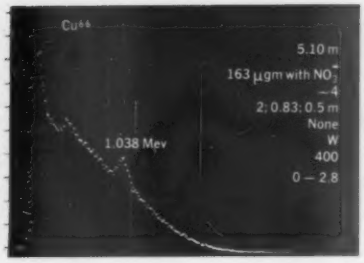


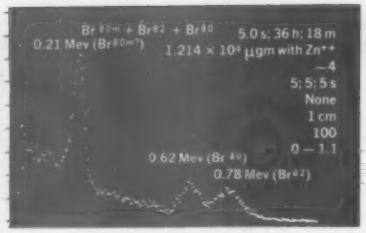


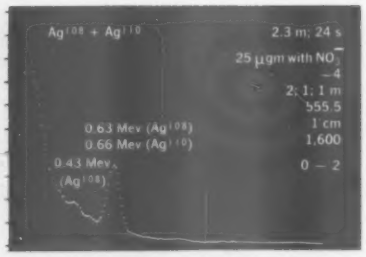


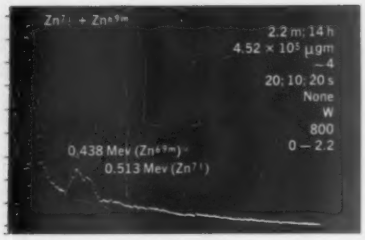


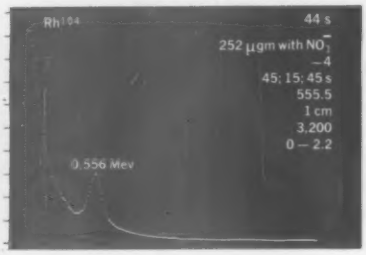


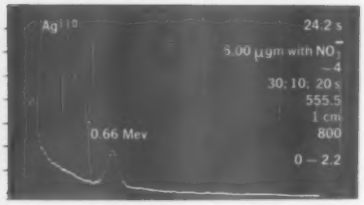

Cu64
5.10 m
163 μgm with NO3−
−4
2; 0.83; 0.5 m
None
W
400
0 — 2.8
1.038 Mev

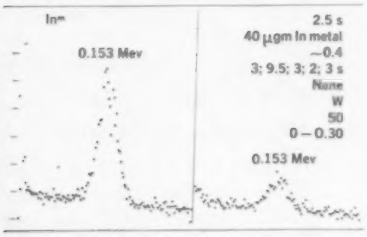

Br80m + Br82 + Br80
5.0 s; 36 h; 18 m
0.21 Mev (Br80m)
1.214 × 10⁴ μgm with Zn++
−4
5; 5; 5 s
None
1 cm
100
0 — 1.1
0.62 Mev (Br80)
0.78 Mev (Br82)


Ag108 + Ag110
2.3 m; 24 s
25 μgm with NO3−
−4
2; 1; 1 m
555.5
1 cm
1,600
0 — 2
0.63 Mev (Ag108)
0.66 Mev (Ag110)
0.43 Mev (Ag108)

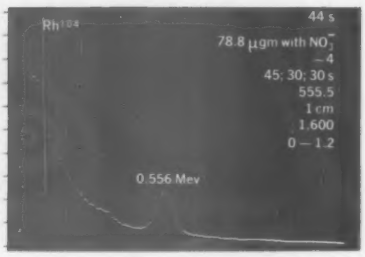

Zn71 + Zn69m
2.2 m; 14 h
4.52 × 10⁵ μgm
−4
20; 10; 20 s
None
W
800
0 — 2.2
0.438 Mev (Zn69m)
0.513 Mev (Zn71)

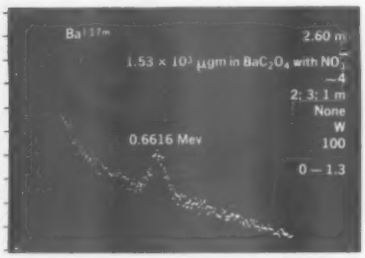

Rh104
44 s
252 μgm with NO3−
−4
45; 15; 45 s
555.5
1 cm
3,200
0 — 2.2
0.556 Mev


Ag110
24.2 s
5.00 μgm with NO3−
−4
30; 10; 20 s
555.5
1 cm
800
0 — 2.2
0.66 Mev

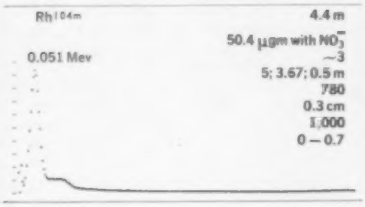

Inm
2.5 s
40 μgm In metal
−0.4
3; 9.5; 3; 2; 3 s
None
W
50
0 — 0.30
0.153 Mev
0.153 Mev

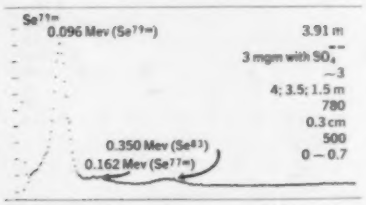
Ge69m
48 s
2.5 × 10² μgm in GeO2
−4
50; 30; 30 s
None
W
800
0 — 0.5 +
0.139 Mev

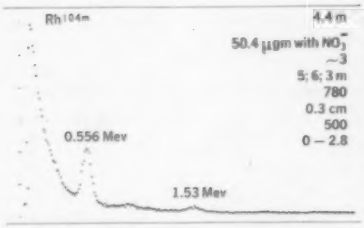

Rh104
44 s
78.8 μgm with NO3−
−4
45; 30; 30 s
555.5
1 cm
1,600
0 — 1.2
0.556 Mev

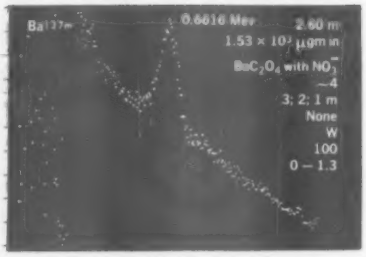

Ba137m
2.60 m
1.53 × 10³ μgm in BaC2O4 with NO3−
−4
2; 3; 1 m
None
W
100
0 — 1.3
0.6616 Mev

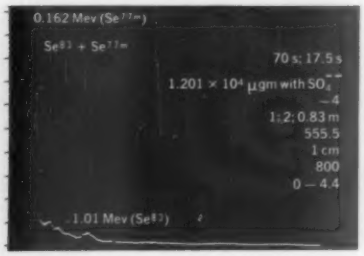
Se77m
17.5 s
12.7 μgm with SO4−−
−4
20; 15; 15 s
None
W
400
0 — 0.5 +
0.162 Mev


Rh104m
4.4 m
50.4 μgm with NO3−
−3
5; 3.67; 0.5 m
780
0.3 cm
1,000
0 — 0.7
0.051 Mev

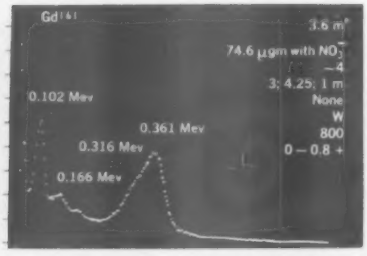

Se79m
3.91 m
3 mgm with SO4−−
−3
4; 3.5; 1.5 m
780
0.3 cm
500
0 — 0.7
0.096 Mev (Se79m)
0.350 Mev (Se83)
0.162 Mev (Se77m)


Rh104m
4.4 m
50.4 μgm with NO3−
−3
5; 6; 3 m
780
0.3 cm
500
0 — 2.8
0.556 Mev
1.53 Mev

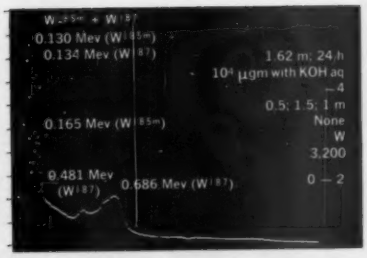

Ba137m
0.6616 Mev
2.60 m
1.53 × 10³ μgm in
BaC2O4 with NO3−
−4
3; 2; 1 m
None
W
100
0 — 1.3

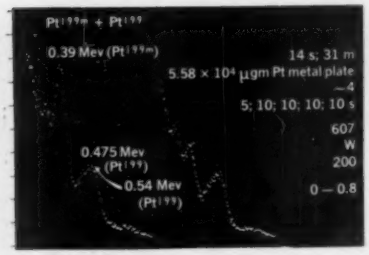

0.162 Mev (Se77m)
Se83 + Se77m
70 s; 17.5 s
1.201 × 10⁴ μgm with SO4−−
−4
1; 2; 0.83 m
555.5
1 cm
800
0 — 4.4
1.01 Mev (Se83)

Ag108
2.3 m
1.006 μgm with NO3−
−4
2; 2; 1 m
555.5
1 cm
3,200
0 — 2.5
0.43 Mev
0.511 Mev (annihilation)
0.63 Mev

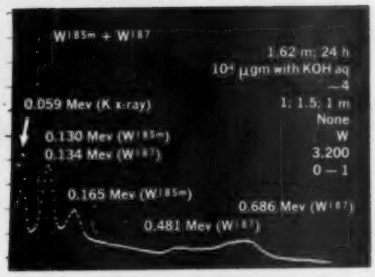

Gd161
3.6 m
74.6 μgm with NO3−
−4
3; 4.25; 1 m
None
W
800
0 — 0.8 +
0.102 Mev
0.361 Mev
0.316 Mev
0.166 Mev

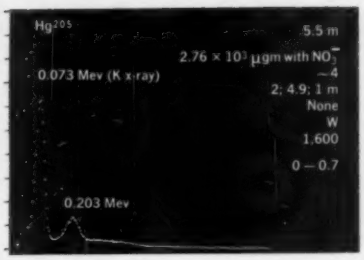
Dy165m
1.25 m
0.649 μgm with NO3−
−4
1; 1; 1 m
None
W
1,600
0 — 1.1
0.108 Mev
0.52 Mev

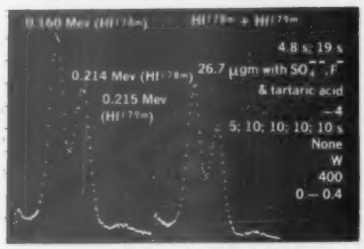

W185m + W187
0.130 Mev (W185m)
0.134 Mev (W187)
1.62 m; 24 h
10⁴ μgm with KOH aq
−4
0.5; 1.5; 1 m
None
W
3,200
0 — 2
0.165 Mev (W185m)
0.481 Mev (W187)
0.686 Mev (W187)

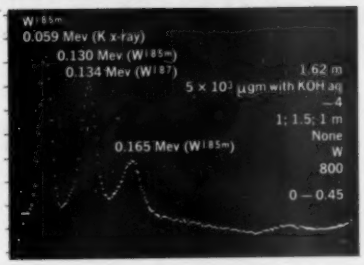

Pt199m + Pt199
0.39 Mev (Pt199m)
14 s; 31 m
5.58 × 10⁴ μgm Pt metal plate
−4
5; 10; 10; 10; 10 s
607
W
200
0.475 Mev (Pt199)
0.54 Mev (Pt199)
0 — 0.8

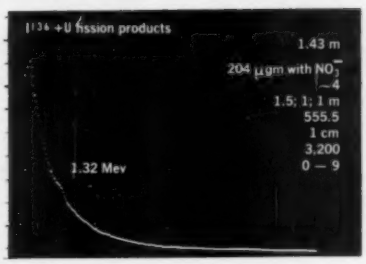
Dy165m
1.25 m
3.25 μgm with NO3−
−0.5
30; 10; 30; 10; 30 s
None
W
100
0 — 0.2
0.108 Mev


W185m + W187
1.62 m; 24 h
10⁴ μgm with KOH aq
−4
0.059 Mev (K x-ray)
1; 1.5; 1 m
None
W
3,200
0 — 1
0.130 Mev (W185m)
0.134 Mev (W187)
0.165 Mev (W185m)
0.686 Mev (W187)
0.481 Mev (W187)

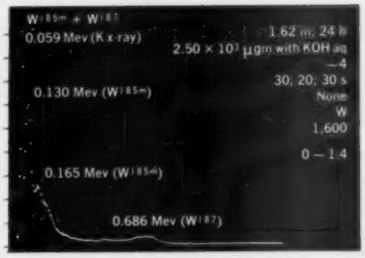

Hg205
5.5 m
2.76 × 10³ μgm with NO3−
−4
0.073 Mev (K x-ray)
2; 4.9; 1 m
None
W
1,600
0 — 0.7
0.203 Mev

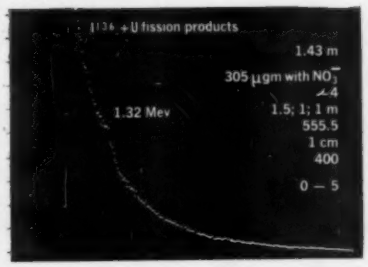

0.160 Mev (Hf178m)
Hf178m + Hf179m
4.8 s; 19 s
26.7 μgm with SO4−−, F−
& tartaric acid
−4
5; 10; 10; 10; 10 s
None
W
400
0 — 0.4
0.214 Mev (Hf178m)
0.215 Mev (Hf179m)

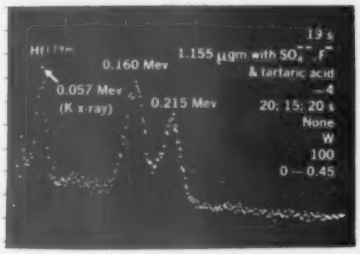

W185m
0.059 Mev (K x-ray)
0.130 Mev (W185m)
0.134 Mev (W187)
1.62 m
5 × 10³ μgm with KOH aq
−4
1; 1.5; 1 m
None
W
800
0 — 0.45
0.165 Mev (W185m)

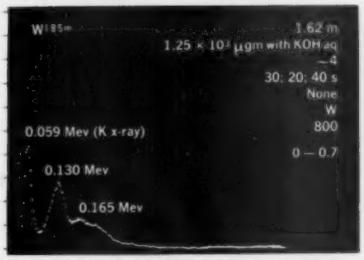

I136 + U fission products
1.43 m
204 μgm with NO3−
−4
1.5; 1; 1 m
555.5
1 cm
3,200
0 — 9
1.32 Mev

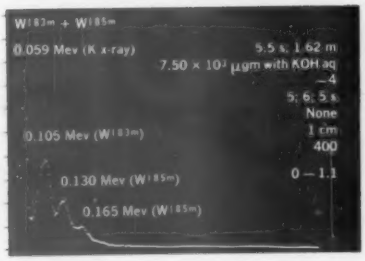
Hf179m
19 s
1.60 μgm with SO4−−, F−
& tartaric acid
−4
20; 15; 20 s
None
W
800
0 — 1.0
0.160 Mev
0.215 Mev

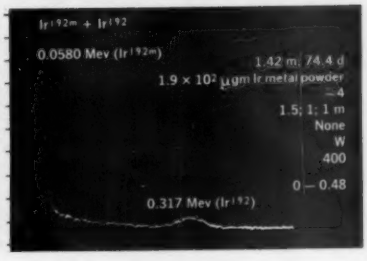

W185m + W187
0.059 Mev (K x-ray)
1.62 m; 24 h
2.50 × 10³ μgm with KOH aq
−4
30; 20; 30 s
None
W
1,600
0 — 1.4
0.130 Mev (W185m)
0.165 Mev (W185m)
0.686 Mev (W187)

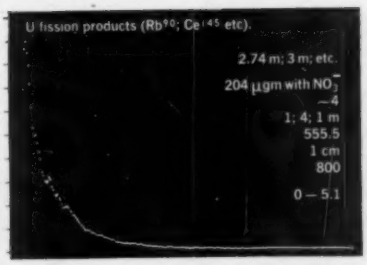

I136 + U fission products
1.43 m
305 μgm with NO3−
−4
1.5; 1; 1 m
555.5
1 cm
400
0 — 5
1.32 Mev

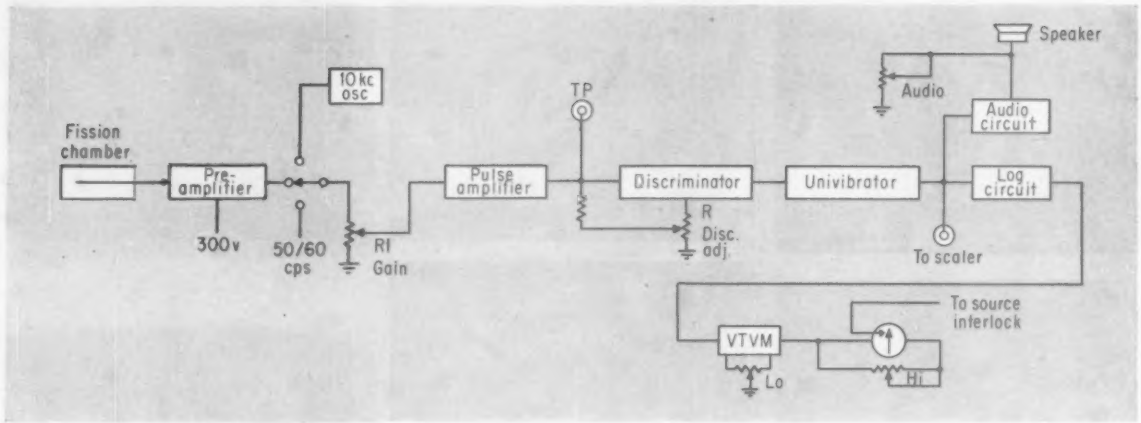

Hf179m
19 s
1.155 μgm with SO4−−, F−
& tartaric acid
−4
20; 15; 20 s
None
W
100
0 — 0.45
0.160 Mev
0.057 Mev (K x-ray)
0.215 Mev


W185m
1.62 m
1.25 × 10³ μgm with KOH aq
−4
30; 20; 40 s
None
W
800
0 — 0.7
0.059 Mev (K x-ray)
0.130 Mev
0.165 Mev


W183m + W185m
0.059 Mev (K x-ray)
5.5 s; 1.62 m
7.50 × 10² μgm with KOH aq
−4
5; 6; 5 s
None
1 cm
400
0 — 1.1
0.105 Mev (W183m)
0.130 Mev (W185m)
0.165 Mev (W185m)


Ir192m + Ir192
0.0580 Mev (Ir192m)
1.42 m; 74.4 d
1.9 × 10² μgm Ir metal powder
−4
1.5; 1; 1 m
None
W
400
0 — 0.48
0.317 Mev (Ir192)


U fission products (Rb90; Ce145 etc).
2.74 m; 3 m; etc.
204 μgm with NO3−
−4
1; 4; 1 m
555.5
1 cm
800
0 — 5.1



Transistor Counting-Rate Channel for Triga Reactors

To take the reactor from the source range to intermediate-power range during startup, Triga operators rely on a compact channel that responds with ~0.25-μsec rise time to 200-μv pulses from a fission chamber

by JOHN H. CAWLEY, *General Atomic Division, General Dynamics Corporation, San Diego, California*

DURING THE PAST THREE YEARS, 21 Triga 10–100-kw training and research reactors have been installed or are under construction. All have a transistor counting-rate channel to indicate power level during startup. The transistor equipment weighs and occupies space about a third that of vacuum-tube equipment. Also, it requires much less power to operate.

A reactor operator needs counting-rate instrumentation to bring a reactor safely from source level [~10–15 cps, 10 mw(th)] up to intermediate power levels. Four decades usually are enough; from this level on to full power he uses other instruments.

Normally a counting-rate channel gives both a linear and a logarithmic presentation. An output that drives a scalar and another that gives an audible signal are particularly valuable when one is operating at low counting rates.

Figure 1 shows the Triga counting-rate circuit. Figure 2 shows the reactor operator's console. All circuits in the console are mounted on fiberglass printed-circuit boards and are treated for moisture protection. Individual circuits are mounted as plug-in units for easy checking and replacement. The logging diode circuit is encapsulated in a silicone silastic. The 8-in.-high counting-rate channel that uses transistors draws less than 10 watts from the line and weighs ~25 lb. It replaces vacuum-tube equipment that is ~21 in. high, requires ~250 watts and weighs over 75 lb.

Triga does not need a linear counting-rate channel because the linear power recorder indicates source level and the log N recorder functions to within a half decade of source level.

Pulse Preamplifier

To detect slow neutrons, Triga uses a fission chamber that produces pulses whose amplitude is ~200 μv with a rise time of ~0.25 μsec. About 20 ft of

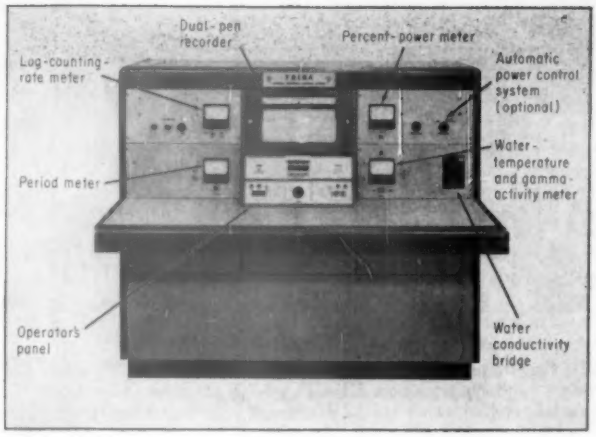


FIG. 1. COUNTING-RATE CHANNEL of Triga 10–100-kw research reactor gets ~200-μv pulses (with ~0.25-μsec rise time) from fission chamber (next to core) that travel along ~20 ft of low-noise coaxial cable to low-noise preamplifier on bridge above core. Preamplifier drives pulses along 100 ft of non-terminated coaxial cable to four-stage amplifier in control console; then pulses go to Schmitt trigger-type discriminator, pulse shapers and diode storage counters. Also provided are built in calibration circuit and a pulse-type amplifier for an 8-in. speaker that can alert operator to reactor condition

FIG. 2. OPERATOR CONSOLE for Triga Mark-2 reactor has 8-in high count-rate channel (except for preamplifier) at upper left in 11 × 7-in. chassis. High-low calibrate controls for the vacuum-tube voltmeter log portion of the circuit are at the panel front for easy access. At console center, pushbuttons actuate control rods and recorder shows power (log and linear)

low-noise coaxial cable connects the fission chamber near the reactor core to the pulse preamplifier on the bridge over the core.

Generally an ion chamber, or fission chamber, is thought of as an infinite-impedance device. Thus vacuum-tube circuits with grid impedances of 1 megohm or more have been used to amplify fission-chamber pulses. Actually, a high source resistance is the low-noise operating condition for a vacuum tube. But transistor amplifiers operate with lowest noise when driven by source resistances less than 2,500 ohms (*1*). For instance, consider a fission chamber (Fig. 3) with chamber inter-electrode capacitance = C_c = 200 μμf, pulse rise time = T_r = 0.25 μsec, with 20 ft of coaxial cable from chamber to preamplifier distributed capacitance = C_c = 20 μμf/ft. Then equivalent bandwidth ≈ (0.4/0.25) = 1.6 Mc/sec, and $Z_{out} = (2\pi f C_T)^{-1} \approx 167$ ohms. Thus a properly designed transistor preamplifier with its inherently small input impedance should match the equivalent chamber output impedance very well, and at the same time operate with little noise.

Pulse differentiation. The signal size at the chamber output depends on the quantity of charge (q) that arrives at the collecting electrode. If the total capacitance of the chamber plus that of the cable is C, then the output voltage is q/C. Rise time is the time during which the charge arrives at the collecting electrode. The fall time depends on the chamber output circuit resistance (R) and the total capacitance (C). If R is large (1–100 megohms), as in a vacuum-tube input circuit, the voltage pulse dies out slowly at an exponential rate. But if R is small, as it can be in a transistor amplifier, it, along with the total capacitance of chamber and cable, serves as the master differentiating time constant of the system. By making the amplifier input resistance ~2,000 ohms, the RC differentiating time is a little over 1 μsec. This low value of input resistance does not reduce pulse amplitude unless the RC product is made comparable to the pulse rise time of 0.25 μsec. This time constant determines pulse shape. All other time constants, including amplifier coupling networks, must be made long with respect to this 1-μsec time constant. If a short time constant is introduced later in the system, the base line will overshoot—interfering with pulse counting.

Preamplifier noise. The preamplifier must raise the nominal 200-μv pulse to a more useful value. The preamplifier noise must be low so it will not mask or interfere with incoming pulses.

The theory of noise has been considered extensively (*2, 3*). Transistors have four types of noise sources:

Partition noise = $i_p = [2eI_c(1-\alpha)B_w]^{1/2}$

Shot noise = $i_s = (2eI_{co}B_w)^{1/2}$

Thermal noise = $v = (1.6 \times 10^{-20} R B_w)^{1/2}$ at room temperature

Flicker noise = $F^{-1}v = K(VB_w/F)^{1/2}$

A high-frequency germanium transistor

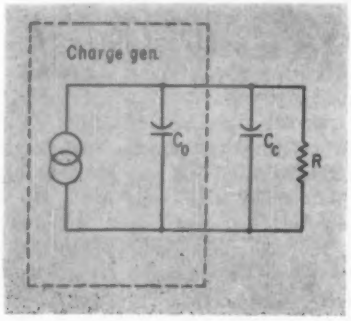


FIG. 3. EQUIVALENT CIRCUIT of fission chamber and connecting coaxial cable

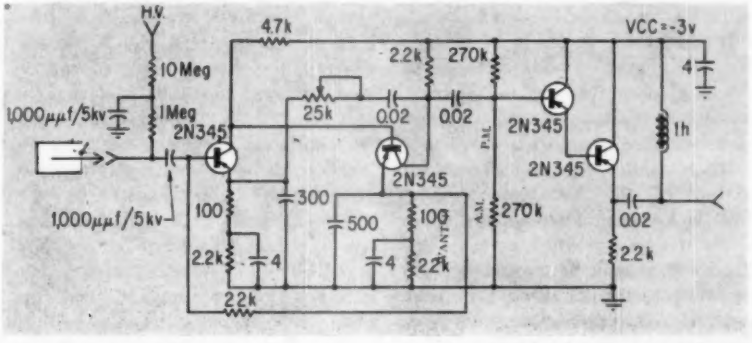


FIG. 4. PULSE PREAMPLIFIER characteristics are: Z_{in} = 2,200 ohms, Z_{out} ≈ 50 ohms, A_v = 30, T_r ≈ 30 mμsec, noise factor = 5 db

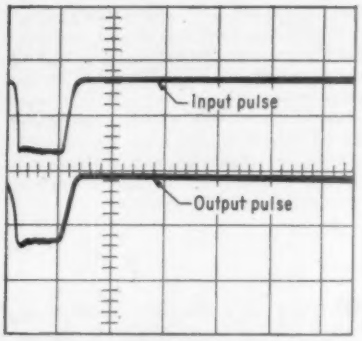


FIG. 5. PREAMPLIFIER PULSES—input pulse and amplified output pulse; voltage gain is 30 and sweep is 0.5 μsec/cm

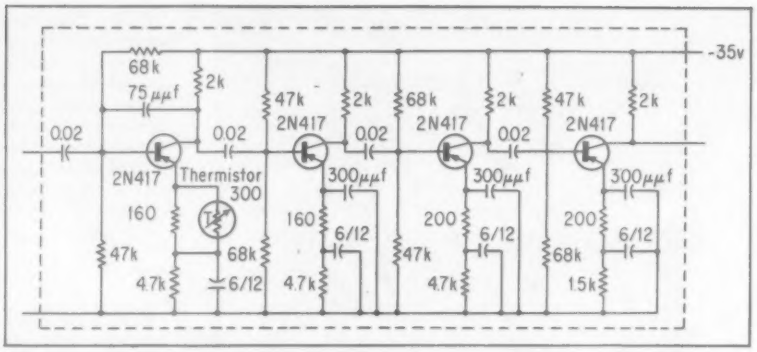


FIG. 6. PULSE AMPLIFIER is four-stage common-emitter-connected unit with ~2,000 voltage gain. It has germanium switching transistors (2N417). Pulse rise times of a few tenths of a microsecond must be handled, so we use RC degeneration in the emitter circuit

with a low I_{co} and a high α generally has little noise. The optimum source resistance for a low-noise transistor amplifier is 200–2,000 ohms, regardless of transistor connection (*1*). A low value of collector-to-emitter voltage minimizes effects of statistical fluctuations of current between base and collector and reduces the surface leakage current (I_{co}). A collector voltage less than 1 volt is desirable. The emitter current also should be selected for an optimum value of noise figure; emitter currents of ~100–400 μamp are best. If the selected value of I_e is too small, the transistor current gain falls off, the input impedance rises, dynamic range is reduced and noise increases, especially at the high-frequency end of the band.

Designers should follow five simple rules for a low-noise pulse preamplifier (a) select transistors of low-noise figure, (b) select transistors with high $f_{\alpha co}$ and low I_{co}, (c) select proper source resistance, (d) select proper operating point and (e) stabilize the operating point with feedback.

Preamplifier circuit. Feedback can be used to trade amplification for bandwidth, while the feedback keeps constant the product of voltage amplification and bandwidth (Fig. 4). When a low source impedance is used, an unbypassed emitter resistor increases bandwidth without loss of gain-bandwidth product (*4, 5*). The feedback loop from the low-impedance second emitter to the first base provides a nearly perfect trade of gain for bandwidth and also tends to temperature-stabilize the amplifier. Addition of feedback from the second collector to the first emitter increases the effective bandwidth about 15%. Feedback is ~15 db in this loop.

The cascaded emitter-follower output provides a cable-driving impedance of 30–50 ohms. This system will drive cables as long as 100 ft without appreciably altering wave shape. With short lengths of terminated cable, rise times are 20–50 mμsec. By choosing the first transistor properly, a noise valve of 4–5 db can be obtained.

The preamplifier characteristics are Z_{in} = 2,200 ohms, $Z_{out} \approx 50$ ohms, $A_v = 30$, $T_r \approx 30$ mμsec, noise factor = 5 db. The −3-volt d-c bias is fed to the preamplifier over the signal-carrying coaxial cable. It is decoupled at both the main chassis in the console and at the preamplifier by a 10-mh choke and a 4-μf condenser. This system reduces the number of interconnecting cables between the main console and the preamplifier, with no appreciable pulse degeneration (Fig. 5).

Pulse Amplifier

The pulse amplifier (Fig. 6) is a four-stage common-emitter-connected unit with a voltage gain of ~2,000. Although each 2N417 germanium switching transistor has an $f_{\alpha co}$ of ~20 Mc/sec when connected in the common emitter configuration, its cutoff frequency is only 200–300 kc. Pulse rise times of a few tenths of a microsecond must be handled; therefore we use *RC* degeneration in the emitter circuit.

The amplitude of the incoming negative pulse from the preamplifier normally is ~5–10 mv. Collector capacitance is inversely proportional to collector voltage; so a large collector voltage (−35 volts) and small load resistors (2,000 ohms) provide a good compromise between rise time and voltage gain. Each stage is biased selectively so negative pulses will drive up the load line and positive pulses will drive down the load line. This gives a simple wide-band amplifier of greatest dynamic range. In addition, any positive component of the differentiated input pulse is attenuated gradually and does not appear in the output pulse. Emitter degeneration is designed to expand the bandwidth while holding the gain-bandwidth product constant. This is accomplished by making the emitter *RC* time constant slightly longer than the collector time constant.

To hold the over-all amplifier gain constant to ~1 db over the working range from room temperature to 45°C, we insert a thermistor network in the first emitter circuit. Large values of emitter resistance in the emitters of each stage stabilize emitter-current bias. The negative-going output pulse has a maximum amplitude of ~10 volts and a rise time of 0.2 μsec.

Discriminator

The discriminator is a modified direct-coupled Schmitt trigger circuit with an emitter-follower output (Fig. 7). An emitter-follower also provides the low source driving impedance needed to give this circuit a reasonably reproducible signal threshold. A 10-turn potentiometer in the common emitter circuit gives a variable bias to the first-stage base. This is the discriminator level control the operator uses to reject pulses of less than the desired amplitude, such as those produced by gamma rays.

The Schmitt trigger generally is superior to the more common variable-

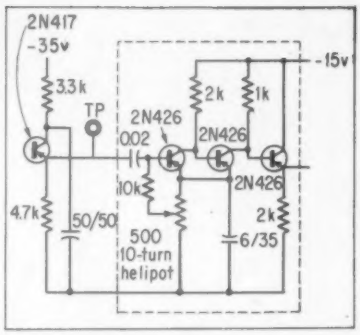


FIG. 7. PULSE DISCRIMINATOR is of modified direct-coupled Schmitt trigger-circuit type with emitter-follower output

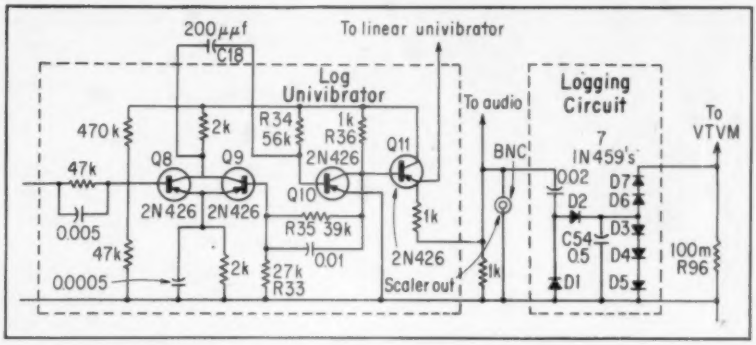


FIG. 8. PULSE SHAPER AND LOGGING CIRCUIT. Shapers standardize pulse width and height; log univibrator consists of transistors Q8 through Q11. Log counting-rate circuit is a typical storage counter; all diodes are of the 1N459 silicon type

bias emitter-follower when used in this application because of its sharper threshold (~0.2 volt). The bias point is stable over the designated temperature range to ~0.2 volt, which is sufficient. We obtain a 6-volt output pulse with ~0.2-μsec rise time.

The pulse shapers standardize the pulse width and height. Figure 8 shows the log univibrator, which consists of transistors Q8–Q11. Q8 serves as a steering circuit that feeds a positive pulse to the collector of Q9. Q10, which normally is conducting, is turned off and Q9 is brought into conduction. This state is held for a period determined mainly by the time constant formed by R34 and C18.

The output pulse height is held constant because of Q10 (which is grounded). It establishes the output pulse height as being equal to that of the regulated supply voltage less the drop in R36, which is due to I_{co} and the bias current in the bleeder consisting of R33 and R35. Thus we must pick transistors with low base-collector leakage current (I_{co}). Q11 is an emitter-follower that provides a low impedance output with a negative-going pulse. The pulse width is fixed at a nominal 2 μsec.

Log Counting-Rate Circuit

The log counting-rate circuit is a typical storage counter (*6*). In Fig. 8, C53 charges through D1 with a negative pulse input and discharges through D2, D3, D4 and D5. The capacitor C54 averages the charge. All diodes are 1N459 silicon diodes. The forward characteristic of D3, D4, and D5 func-

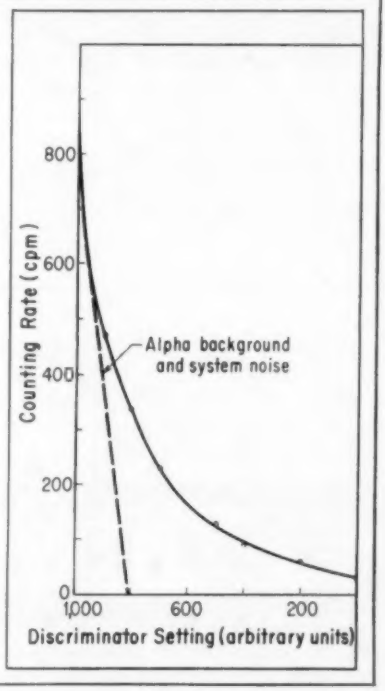
Operating Experience with Nine Trigas

There have been no installation problems caused by noise or excess cable capacity on the long-cable runs in the nine Triga reactors installed to date. The cable between the WL-6976 fission chamber and the preamplifier is 15–20 ft long; cables as long as 140 ft connect preamplifier to console.

The curve shows a typical integral-bias curve taken with a ½-curie Po-Be source and water moderator before fuel is loaded in the core. A family of integral-bias curves can be plotted when the fission chamber is moved to different positions relative to the source. Normally, the chamber is positioned to give the lowest source counting rate (~5–15 cps) after fuel is loaded (so multiplication due to fuel can be accounted for).

The presence of high gamma background in the operating reactor reduces the height of the neutron pulses, and this reduces the count rate. A pileup of gamma pulses might require a higher discriminator setting, which also reduces the counting rate. In the presence of a high gamma background, one has only to pull the source and check for the absence of neutrons to determine whether the discriminator has been set properly to discriminate against gammas. With the discriminator set properly neutron multiplication will be indicated when the first safety rod is raised.

The over-all temperature stability of this equipment has been satisfactory. A ~2% variation in readings (linear scale) can be expected as temperature varies from 20 to 45°C. Although this is satisfactory for this application, temperature can be compensated for simply by adding a corrective network to the meter circuit.



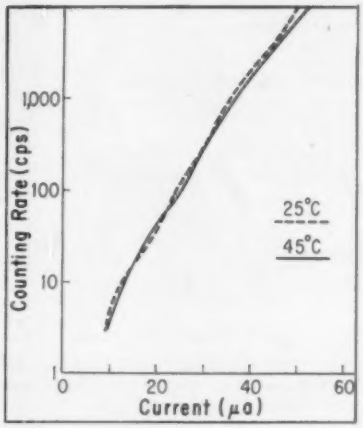


FIG. 9. TEMPERATURE INSENSITIVITY of log counting-rate characteristic is shown for service at 25°C and 45°C over circuit's four decades. Transistor circuit could have been used here instead of vacuum tube, but cost of stable silicon transistor circuitry was not warranted

tions as a logging diode. D6, D7, and R96 form a voltage divider. The values are proportioned so that the temperature-sensitive characteristic of the series diodes compensates for those in the shunt leg, thus holding output voltage across R96 relatively constant with changing temperature.

The log circuit covers four decades to 10,000 cps. Figure 9 shows the log characteristic and its temperature insensitivity. These curves were plotted by using the vacuum-tube voltmeter, which is a typical twin-triode circuit of good stability. We use a vacuum tube here because its high grid impedance prevents loading the log circuit. We could use transistor circuitry, but the expense of stable silicon circuitry is not warranted. The log counting rate can be recorded in the source range by a strip-chart recorder placed across a resistor in series with the log meter.

Audio and Calibration

An output of the log univibrator also drives the audio circuit, which gives the operator an audible indication of counting rate (Fig. 10). Q23 serves the dual purpose of a pulse inverter and isolation amplifier. Q24, Q25, and Q26 normally are held off until triggered on. Regeneration pushes all three transistors simultaneously into conduction, producing a fast rising pulse of ~12 volts (variable) across the 50-ohm volume control. The pulse width is controlled by R79, R77, and C41 (7). The output drives an 8-in. speaker.

Calibration circuits. Calibration internally checks the log and linear circuits at 60 and 10,000 pps. These frequencies are derived from the power line and a 10,000-cps oscillator (Fig. 11). The relaxation-type oscillator gives a 10,000-cps sawtooth calibration signal. In this simple circuit, which utilizes a double-base diode and a *pnp* silicon transistor, C charges through R until the voltage exceeds a value determined by ηV_{bb} where η is the intrinsic standoff ratio of the double-base diode. At this point the capacitor discharges through the emitter base-one diode, thus generating a sawtooth wave form.

A silicon *pnp* transistor serves as an emitter follower. The advantages of this configuration are the low output impedance and the temperature compensation given by the partial cancellation of I_{co} of the double-base diode by the I_{co} of the junction transistor. The thermistor network in the RC charging

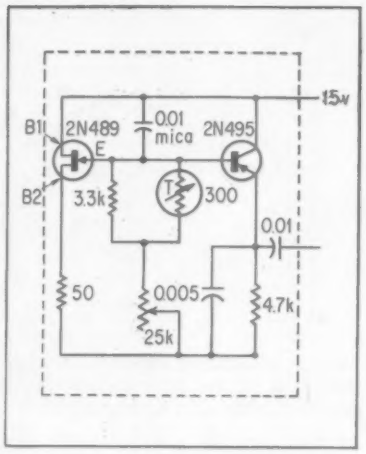


FIG. 11. CALIBRATION OSCILLATOR produces 10,000-cps signal by which log and linear circuits can be checked internally; 60-cps frequency from power line also can be used if operator so desires

circuit further compensates for temperature. A frequency stability of 0.5% is easily met with this circuit over a normal working temperature range of 20–50°C.

To simulate fission-counter pulses, these frequencies are applied to a Schmitt trigger-type circuit in which output is differentiated and the positive portion clipped. The resulting pulse is ~1.5 μsec wide. By depressing the calibrate switch to either the 10,000- or 60-pps position, the incoming preamplifier pulse is disconnected and the calibrate pulse is applied to the amplifier input. Thus, not only can the amplifier be calibrated, but the entire chassis can be checked automatically for proper operation.

* * *

The author wishes to thank his colleagues at General Atomic, particularly M. S. Eichen, for their valued help and encouragement.

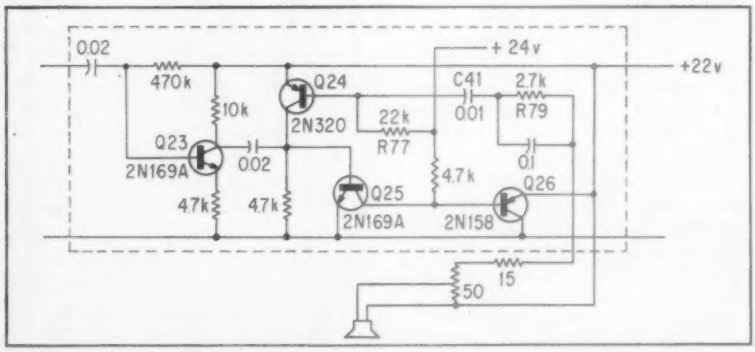


FIG. 10. AUDIO CIRCUIT, driven by signal from log univibrator, adds audible counting-rate signal to meter reading available to operator

BIBLIOGRAPHY

1. L. P. Hunter, "Handbook of Semiconductor Electronics," 1st ed., Sec. 11.9 (McGraw-Hill Book Co., Inc., New York, 1956)
2. A. van der Ziel, "Noise," p. 209 (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1954)
3. A. van der Ziel. Note on shot and partition noise in junction transistors, *J. Appl. Phys.* **25**, 815 (1954)
4. L. P. Hunter, "Handbook of Semiconductor Electronics," 1st ed., Sec. 12.2 (McGraw-Hill Book Co., Inc., New York, 1956)
5. C. A. Steggerda. A study of gain and bandwidth in transistor video amplifiers, Report No. 242 (Philco Corp. Research Division)
6. W. C. Elmore, M. Sands, *Natl. Nuclear Energy Ser. Div. V, Electronics 1*, **280** (1949)
7. D. W. R. McKinley. Transistor relays have low idling current, *Electronics* **30**, No. 12, 147 (1957)

These 300 pound sound castings of near theoretical density (11.71 gms/cc) have a purity greater than 99.5% and an extremely low rare earth content. Machined Thorium castings like these are produced routinely at the Davison nuclear reactor materials plant in Erwin, Tennessee.

Many tons of consistently pure Thorium in powders, compacts and castings have been produced by Davison, recognized for many years as the proven producer of this nuclear grade Thorium. Today, our special melting process gives you the greatest value in Thorium . . . low cost ingots in a range of shapes and sizes to fit your application requirements.

Our research facilities stand ready to serve you, and our analytical laboratories assure you of the precision and accuracy you need on the high cross-section, difficult to analyze trace elements. It adds up to this: no other firm can offer you the experience and ability Davison can as a producer of Thorium metal. For Thorium, call Davison, Ploneer 2-1721 in Erwin, Tennessee.

GRACE

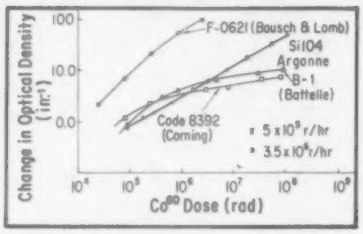
DAVISON CHEMICAL

Erwin, Tennessee

New Glass Is Excellent High-Level Dosimeter

By adding arsenic trioxide (As_2O_3) to a bismuth-lead-borate glass, Adli M. Bishay of Argonne National Laboratory has made a dosimeter that is linear from 10^5 to 10^9 roentgens and nearly free of fading. On exposure to gamma radiation the new glass (named Si 104 by Argonne) shows an increase in optical absorption in a band centered at about 515 mμ (green light). The log of the optical density at this frequency is linear with respect to the log of total exposure (see figure).

Moreover this radiation-induced increase in optical density can be remarkably stable—a sample of Si 104 irradiated to 7.2×10^7 roentgens showed a negligible change in optical density at 515 mμ after storage in the dark at room temperature for 1,000 hr. The optical density, however, of samples irradiated to only 4×10^5 roentgens tended to fade when stored at room temperature. The reason is that irradiation produces another absorption band centered in the ultraviolet at about 370 mμ; apparently this band is wide enough to contribute to the optical density at 515 mμ. But at the same time the ultraviolet band appears to saturate at doses greater than 10^7 roentgens and is subject to fading with time. Taken together, these features of the ultraviolet band explain why the low-dose sample fades and the high-dose sample does not.



OPTICAL DENSITY increases linearly with gamma dose for Argonne Si 104 glass

Even the low-dose fading can be eliminated simply by heating the irradiated sample. A 5×10^5-roentgen sample heated at 130°C for 1 hr showed negligible fading at room temperature over a period of 2,000 hr. The heating tends to eliminate the unstable part of the optical density due to the ultraviolet band while preserving the linearity of the remaining density with dose.

The addition of 2.4 w/o of As_2O_3 to the bismuth-lead-borate glass (other constituents: 52 w/o Bi_2O_3; 24 w/o B_2O_3; 17 w/o PbO; 4.5 w/o SiO_2) apparently causes the absorption band at 515 mμ to appear under irradiation through the photochemical reduction of bismuth trioxide to bismuth by the arsenic trioxide.

The glass has the added advantage that, although it is colorless to begin with, during exposure it develops a magenta color that can serve as a semiquantitative visual test.

[A. M. Bishay, Physics and Chemistry of Glasses **2**, No. 2, 33 (April 1961)]

Cerenkov Counter for Fuel-Burst Detection

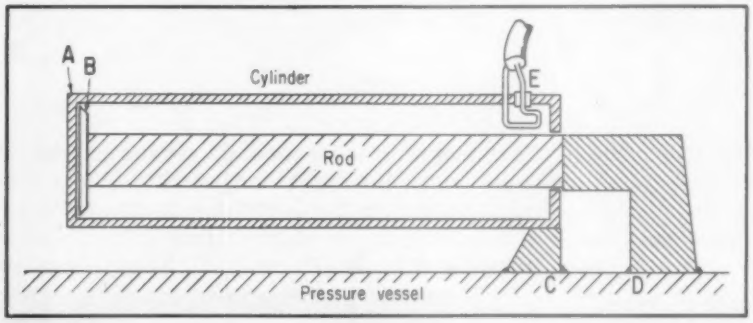
The Cerenkov counter shows promise as a moniter of fission-product activity in failed-fuel-element detection systems. Such a counter would scan samples of core-outlet water for the Cerenkov light emitted by the high-energy beta particles from short-lived fission products as the particles travel through the water. An alternative to the present-day gamma-ray-spectrometer and delayed-neutron monitors, the Cerenkov counter would be fast and sensitive. In experiments that simulated failed fuel, K. Takumi and S. Yamada (Kitachi Central Research Lab., Tokyo) achieved a 10-to-1 ratio for signal counts to background counts from a fission-product concentration of less than 600 $\mu\mu$c/cm^3. For a typical reactor system this concentration would correspond to the radioactivity released from 1 cm^3 of exposed fuel.

The biggest advantage of the Cerenkov counter is that the light signal is gathered from the water sample itself, which contains the decaying fission products. The counter is biased so that it detects only betas of >5 Mev energy. This criterion eliminates all but five nuclides—Br^{87}, I^{136}, Rb^{90}, Y^{94} and Rb^{88}—with half-lives ranging from 2.7 sec to 18 min.

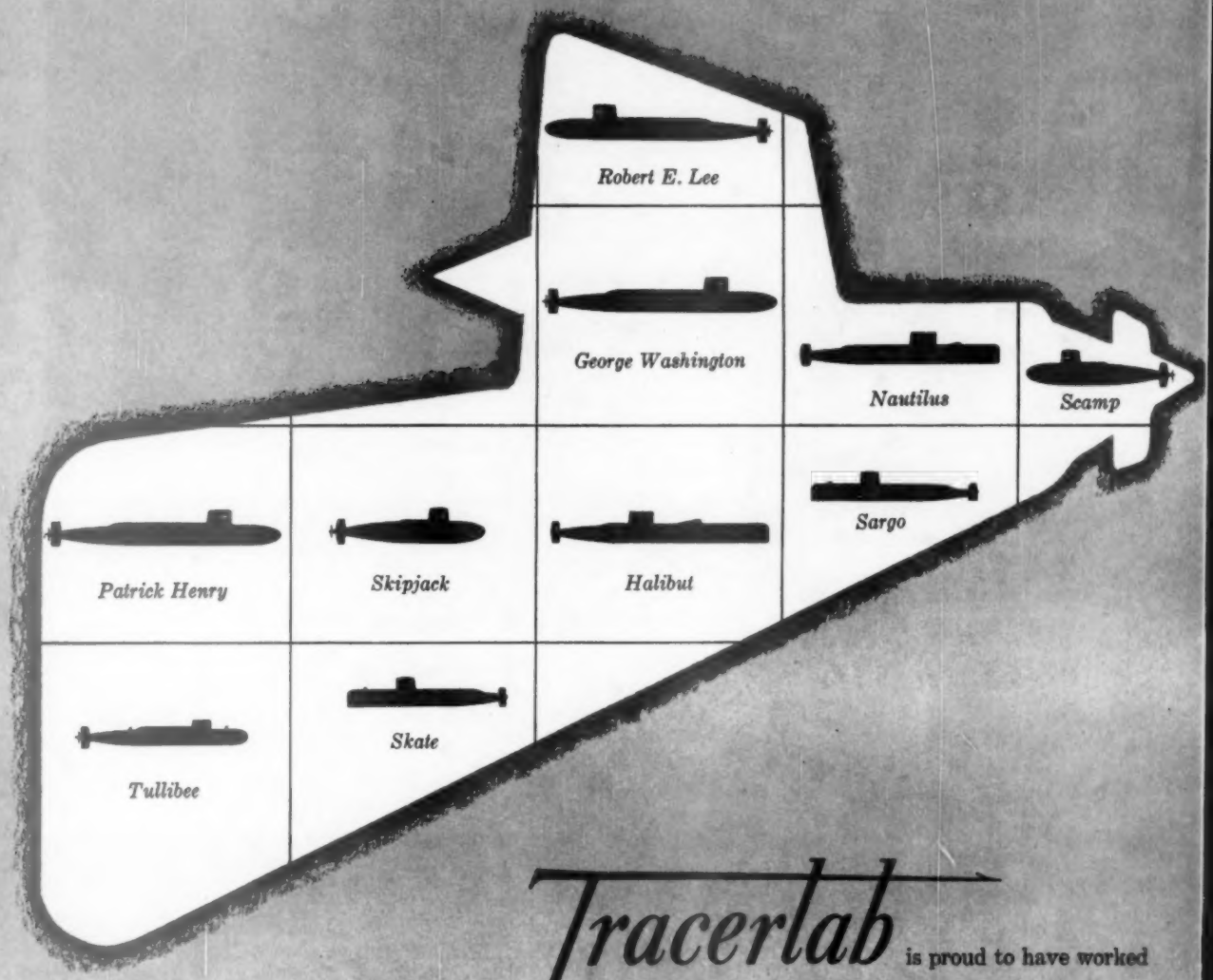
Takumi and Yamada also constructed a Cerenkov system that is capable of functioning as a continuous monitor of liquid wastes with a Sr^{90} sensitivity of <0.3 $\mu\mu$c/cm^3.

(K. Takumi, S. Yamada, Conference on Nuclear Electronics of the International Atomic Energy Agency, Paper NE 29, May 1961)

Variable-Capacitance Strain Gage



NOVEL STRAIN GAGE detects strain in reactor pressure vessel by measuring changes in electrical capacitance between plates A and B that accompany changes in the length CD. Center rod welded to vessel wall at D and hollow cylinder welded to vessel wall at C form conducting loop, which, when excited by oscillator through coupling loop E, oscillates at a frequency that depends on capacitance AB. Device, developed by the United Kingdom Atomic Energy Authority, provides means of remotely monitoring pressure-vessel strain. Gage also can operate at high temperatures and is both rugged and sensitive. For best sensitivity cylinder length should be less than ½ wavelength



Tracerlab is proud to have worked side by side with the U. S. Navy in the "Start-Up" of the above pictured nuclear submarines.

Tracerlab has also contributed to the advancement of the Navy's Nuclear Program by supplying such equipment as the Air Particle Monitor LM-151/WD6; the Alpha Survey Meter AN/PDR56; and the Alpha Survey Meter Training Aid X-11F5.

Tracerlab continues to devote its knowledge and skills toward further strengthening our nuclear Navy.

Tracerlab *Tracerlab* **Government Products Division**

Waltham 54, Mass. · Richmond 3, Calif. · Houston 6, Texas

PERSONAL RADIATION MONITOR

- Loud chirping signals
- Flashing neon lamp
- Unique "on-off" device
- Lightweight . . . only 3½ oz.
- Long battery life
- Based on O.R.N.L. design

Model PRM-253 "Chirpee" is a miniature, lightweight (3½ oz.) radiation monitor that warns the user when he encounters an unexpected radiation field. It features visible and audible warning signals . . . a flashing neon lamp and a "chirping" subminiature speaker. Both are activated simultaneously, at a rate proportional to radiation intensity.

Write for Bulletin N 53

ATOMIC *accessories inc.*

Subsidiary of Baird-Atomic, Inc.
817 W. Merrick Rd., Valley Stream, N. Y.
Represented Nationally by
Baird-Atomic Sales Offices

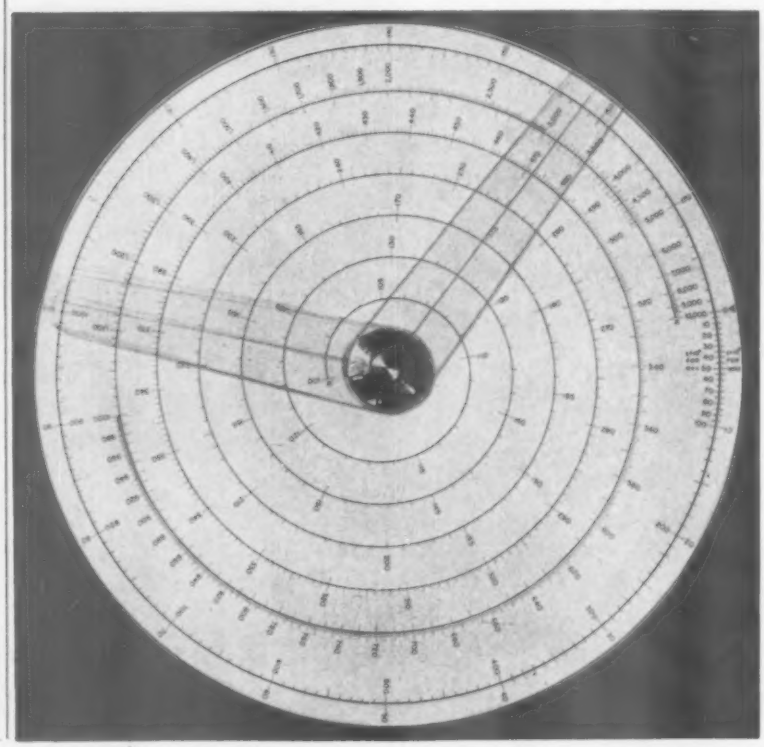
Slide Rule for Making Dead-Time Correction

by JAMES H. SCOTT
United States Atomic Energy Commission, Grand Junction, Colorado

In counting experiments one adjusts the observed counting rate to compensate for instrument dead time (the short time period after receipt of a pulse before the detector or scaler is ready to receive another). The customary formula for this correction is $N = n/(1 - nt)$ where N is the corrected counting rate, n the observed counting rate and t the dead time.

The solution of this formula on a desk calculator becomes tedious and time consuming when many calculations must be made. Graphs of N versus n for various values of t permit faster solutions, but lead to errors and are unhandy to use when many different values of t are involved. I have designed a special purpose slide rule (see figure) that solves the equation quickly, accurately and easily for a large range of counting rates and dead times.

There are three scales on the face of the circular rule. A counting-rate scale ranging from 100 to 10,000 counts per second is laid out along a spiral which unwinds in a clockwise direction. Two dead-time scales are laid out along a circle near the edge of the disc. [The design equation for the counting rate scale is $\phi = 2{,}000 - 200{,}000/(\textit{plotted counting rate})$ where ϕ = angle (measured in degrees) in a clockwise direction between starting point of the spiral and each counting rate (measured in counts per second) plotted on the spiral; the inner dead-time scale is laid out on a scale of 5 μsec/deg, the outer one, 0.5 μsec/deg.] As on an ordinary circular rule, the two index arms can rotate independently, but because the



New B/A Gamma Spectrometer —

luxury features in a compact, economy package

Model 8250 Spectrometer incorporating the All-Electronic Scaler Model 135, the Model 250 Amplifier-Analyzer and Model F-8 Fan Filter Assembly.

Baird-Atomic announces the new Model 8250 single channel Spectrometer which can be quickly and easily calibrated in energy units (Mev) for any energy range from X-rays to cosmic rays. Spectra can be positioned as desired by the high voltage and the gain controls. Any degree of differential operation (relative window width) or integral operation may be obtained.

The Model 8250 is a combination of two instruments just added to the Baird-Atomic line. They are the Model 250 Amplifier-Analyzer and a new all-electronic Model 135 Scaler. The Scaler, which combines a 5 decade, 5 micro-second scaler and an electronic timer on one chassis, is excellent for both general lab counting work and for use with the most sophisticated automatic sample changing systems.

Write today for details on these instruments and their system combinations.

Offices in Cambridge • New York • Philadelphia • Detroit • Cleveland • Washington, D.C. • Atlanta • Dallas • Chicago • Los Angeles • San Francisco • Ottawa, Canada.

Engineers and scientists: *Investigate challenging opportunities with B/A. Write Industrial Relations Director. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.*

B/A **BAIRD-ATOMIC, INC.**

33 university road · cambridge 38, mass.

ADVANCED OPTICS AND ELECTRONICS . . . SERVING SCIENCE

FROM RIGGING...TO REACTORS

MASSACHUSETTS LEADS THE WAY

1961 — Massachusetts makes Naval history again! The cruiser USS Long Beach, recently completed, becomes the Navy's first nuclear powered surface ship. Nearly two centuries ago, the Bay State began its U.S. Naval tradition with the construction of its early rigged frigates. Today, Massachusetts still leads in Naval progress with ship building know-how plus atomic creativity.

If you are in the atomic energy or related fields, we would like to send you important factual information on Massachusetts' advanced nucleonics and industrial productivity.

Write to: MASSACHUSETTS COMMISSION on ATOMIC ENERGY
150 Causeway Street • Boston 14, Massachusetts
All inquiries handled in strictest confidence

This article starts on page 90

friction between them is greater than the friction between the lower arm and the disc, they more easily rotate together as a unit.

To calculate corrected counting rates move the long arm to the observed counting rate, making sure that the short arm follows the motion with no change in the angle between the arms. Read the corrected counting rate where the spiral first intersects the short arm in the clockwise direction. For the outer dead-time scale the numbers on the counting rate spiral are to be multiplied by 10. Thus the outer dead-time scale extends the counting rate range from 100–10,000 cps to 1,000–100,000 cps.

Theoretical Description

To understand mathematically the operation of the rule, we first observe that with the long arm at zero and the short one at the correct dead time the angle $\Delta\phi$ between the arms is proportional to the dead time $\Delta\phi = at$ where a = constant (0.2 deg/μsec for inner dead-time scale and 2 deg/μsec for outer dead-time scale) and t = dead time (in μsec). The angle subtended by the arms on the counting-rate scale is also proportional to the difference between the reciprocals of the two counting rates indicated by the arms $\Delta\phi = b[1/n - 1/N]$ where b = constant (0.2 deg-counts/μsec). If we combine the expressions for $\Delta\phi$ then when $a = 0.2$ (inner dead-time scale) then $0.2t = 0.2 \times [1/n - 1/N]$, or $N = [n/(1 - nt)]$, and when $a = 2$ (outer dead-time scale), $2t = 0.2 \times [1/n - 1/N]$, or $N \times 10 = n \times 10/[1 - (n \times 10)t]$.

Make Your Own Slide Rule

NUCLEONICS will furnish a reproduction of the circular slide-rule face to the reader who would like to construct a rule for dead-time corrections like the one described in this article. For your reproduction on heavy stock suitable for mounting on an ordinary 8 in. circular slide rule, send your name and address and $1.00 to Reader Service Dept.

General Mills "Arms" Trieste to extend ocean knowledge

To enable its oceanographers to actually retrieve mineral and plant life observed in ocean floor explorations, the Navy commissioned General Mills to supply a unique "Mechanical Arm" for the Trieste.

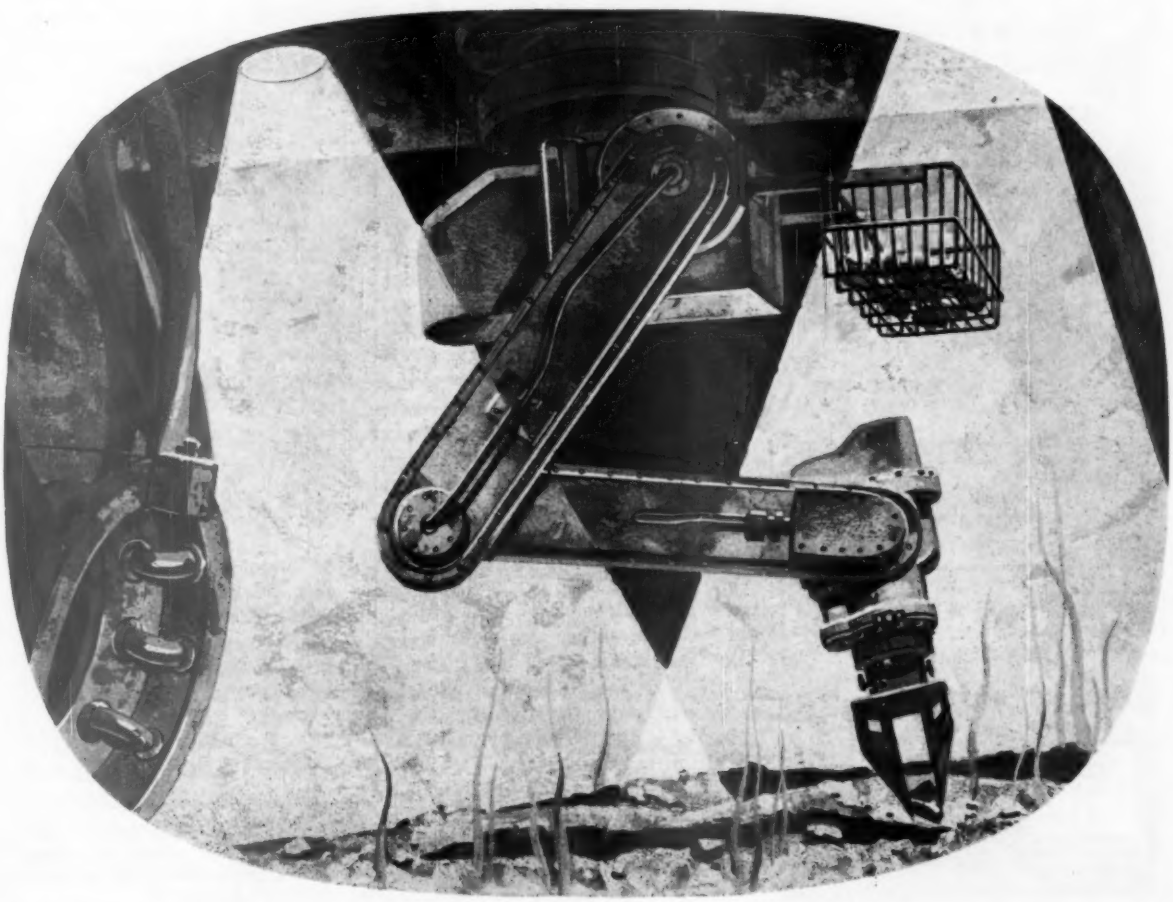
Adaptation of the nuclear industry's most widely used electro-mechanical manipulator, fits the General Mills unit for operation under pressures of 8 to 9 tons per square inch. Trieste operators control the "Arm" from a compact control box with individual lever-action switches to provide direction and variable speed for each of six motions.

During initial test dives in the Pacific this summer, the new Mechanical Arm enabled ocean researchers for the first time to selectively collect samples that may unravel some mysteries of "inner space." Already a pioneer in providing remote handling for most of the nation's nuclear facilities, General Mills is proud to to have been an active participant with the Bureau of Ships and the Office of Naval Research in expanding the horizons of our Nuclear Fleet.

General Mills

MECHANICAL ARMS

Automatic Handling Equipment Department
Minneapolis 13, Minnesota



Industrial Instruments Inc.
covers
THE WHOLE FIELD OF SOLUTION CONDUCTIVITY

from ULTRA PURE WATER to FUMING SULFURIC ACID

from REFRIGERANT BRINES to OVER 300°F

from HIGH VACUUM to 7500 PSI

from 1/100 ML SAMPLES to THE PACIFIC OCEAN

from BATTERY to LINE OPERATION

from 1/1000 CELL CONSTANT to OVER 1000/CM

from PLATINUM ELECTRODES to NO ELECTRODES

from D.C. to 20 KC

from SIMPLE LAB METERS to MULTIPOINT RECORDER CONTROLLERS

from POLISHED FILTRATES to THICK SLURRIES

Write for complete information on Solu Bridges, Solu Meters, Recorders, Larson-Lane Steam and Condensate Analyzers, Thallium Dissolved Oxygen Analyzers, Conductivity Cells and Accessories.

Industrial Instruments Inc.
89 Commerce Road Cedar Grove, Essex County, N. J.

Magnetic Domains Complicate Beta-Backscatter Technique

by DON H. JOHNS and ORVAL R. ALEXANDER

American Can Co., Barrington, Illinois

Localized magnetic fields in thin steel plate can cause large variations in beta-particle backscatter from the plate. Even when the plate is demagnetized (so that the backscatter is uniform as a function of position), the level of backscatter proves to be a function of applied stress. We discovered these spatial and stress-dependent anomalies in an attempt to develop beta-particle backscattering as a means of measuring the tin-coating thickness on commercial tin plate.

Two separate experiments demonstrated conclusively that magnetic fields in the steel were responsible for the observed anomalies. First we scanned several different samples of cold-reduced steel along the rolling direction at points 1 in. apart and at a constant distance from an edge parallel to the rolling direction. Figure 1 shows backscattering responses in arbitrary units for both sides of a typical sample. (In all of our work we used a Sr^{90} beta source.) The curves show a striking effect due to the opposite polarization of opposite sides of the plate.

After the samples were scanned, they were demagnetized and the identical areas rescanned. The considerably more uniform backscattering of the demagnetized samples (see Fig. 1) indicates that the original large variations in backscattering do indeed result from the presence of magnetic fields. The value for the demagnetized backscattering, essentially uniform for each sample, varied from 40 to 65 (arbitrary units) for the samples tested.

In the second experiment we observed the magnetic fields directly. The experiment employed a coil immediately above the sample that induced an alternating voltage in the sample. The magnitude of the voltage was proportional to the strength of the horizontal vector of the magnetic field. Selected areas of samples analyzed by this method showed different magnitudes of induced voltages, thus demonstrating the nonuniformity of the magnetic fields. The induced voltage was constant for a demagnetized sample.

Depends on Applied Stress

Although the backscatter is spatially uniform for demagnetized samples we observed that the level increased with temper (Rockwell hardness). To verify this observation, we measured the backscatter of demagnetized samples as a function of applied stress. Dumbbell-shaped samples cut from several sheets of untinned steel were demagnetized and analyzed with the beta gage. The intensity of beta-particle backscattering was essentially constant for all samples. Each sample was then subjected to varying degrees of stress (within the elastic limit) in an Amsler tensile tester. The samples were analyzed again with the beta gage, demagnetized and then reanalyzed. Figure 2 shows the change in backscatter of the demagnetized samples as a function of the applied stress. There

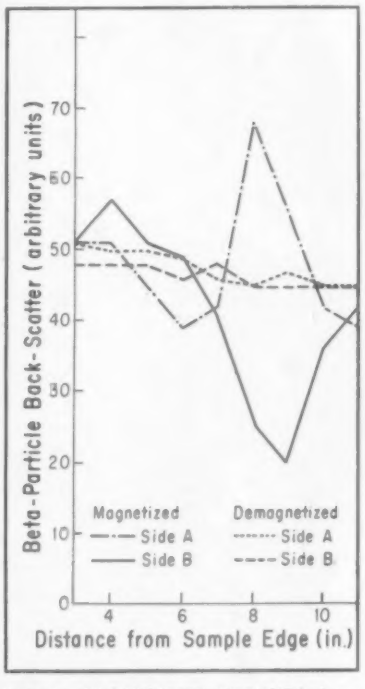


FIG. 1. BACKSCATTER INTENSITY shows large variations with position on sample before demagnetization, almost no variation after demagnetization

NATIONAL FORGE

SUBMARINE COMPONENT BUILDERS FOR THIRTY YEARS

This autoclave body (type 347 stainless), for testing naval nuclear reactor fuel elements is typical of the many products produced for the Navy by National Forge Company during the past three decades.

Other products manufactured by National Forge include periscope tubes, submarine shafts, coupling and clutch components, hydraulic cylinders, tail-plane stocks, rudder stocks, hypervelocity guns and shock tubes.

For one responsible and experienced source in forging, trepanning and hollow boring, machining, autofrettaging and plating to exacting specifications . . . for complete service . . . call National Forge: Area Code 814, LOgan 3-7522 (TWX: YGSV 8454).

NATIONAL FORGE COMPANY

IRVINE, WARREN COUNTY, PENNSYLVANIA

4 ULTRASONIC PROBLEM BUSTERS by BRANSON

FLAW DETECTION

SONORAY® ULTRASONIC FLAW DETECTOR

SONORAY detects and locates flaws. SONORAY measures thickness and detects metallurgical variations.

- compact
- portable
- low cost

$2,750

THICKNESS GAGING

VIDIGAGE®

- thickness gaging from one side
- accurate to ± 0.5%
- easy to operate
- gages metal, plastics, glass
- portable

$1,750

ULTRASONIC PROCESSING

SONIFIER

Emulsifies on a continuous basis up to 20 gallons an hour. Can also be used for dispersion of solids in liquids and for homogenization studies.

$750

ULTRASONIC CLEANING

SONOMATIC

- fully automatic for maximum efficiency
- automatically tunes itself to optimum operating frequency
- activity meter indicates cleaning effectiveness of tank

From $225

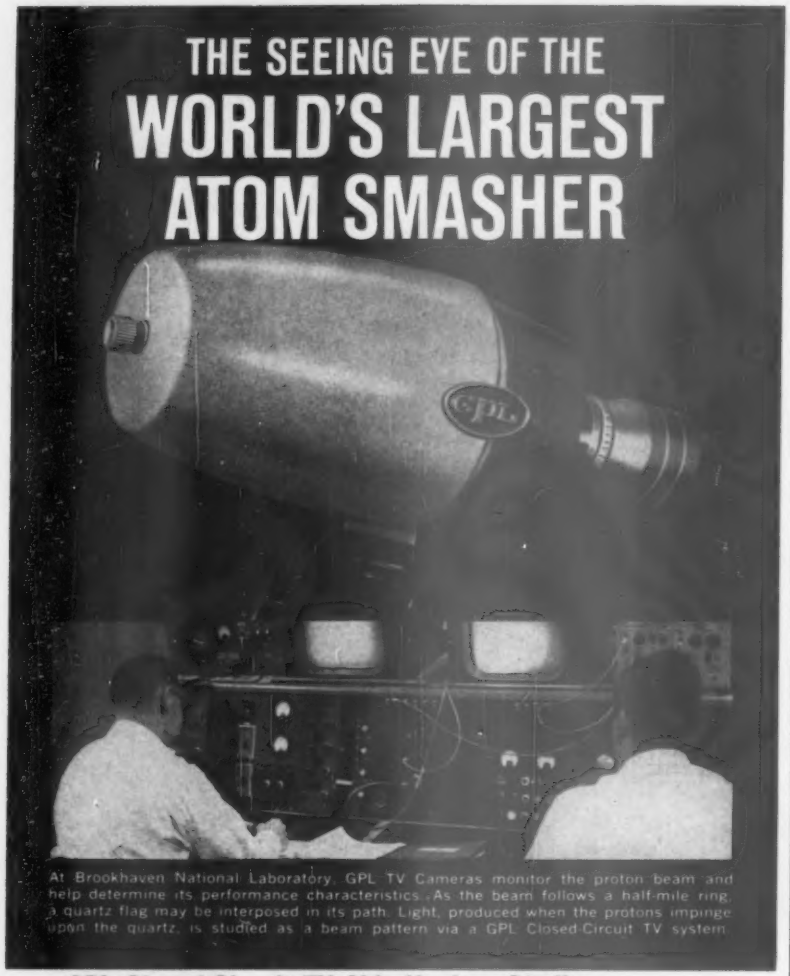
CUSTOM ENGINEERING

Branson's experienced, factory-trained specialists are ready to assist you anywhere in the U. S. for your custom engineering needs. Tell us about your particular problem and Branson's engineering department will try to find the best possible solution in the **shortest** possible time.

BRANSON INSTRUMENTS, INC.

Ultrasonic Power Division
Ultrasonic Test Division

24 Brown House Road, Stamford, Conn.


THE SEEING EYE OF THE
WORLD'S LARGEST
ATOM SMASHER
GPL
At Brookhaven National Laboratory, GPL TV Cameras monitor the proton beam and help determine its performance characteristics. As the beam follows a half-mile ring, a quartz flag may be interposed in its path. Light, produced when the protons impinge upon the quartz, is studied as a beam pattern via a GPL Closed-Circuit TV system

GPL Closed-Circuit TV Aids Nuclear Studies At Many Atomic Research Projects

Nuclear scientists have found a powerful tool in GPL Closed-Circuit TV systems. Immune to radiation, they play an important role in many aspects of nuclear research. Among the functions they perform are: monitoring of beam pattern and positioning in particle accelerators, display of Gausian curve functions and monitoring of remotely controlled counter and collimator gear as well as the surveillance of "hot" areas.

GLP Closed-Circuit TV systems have proved themselves in nuclear research—a fact attested by their use in over fifteen top-name laboratories including:

Argonne National Laboratory
Brookhaven National Laboratory
Convair, Division of General Dynamics
Ethicon, Inc. (Johnson & Johnson)
James Forrestal Research Center (Princeton University)
Metals & Controls Inc.,
A Corporate Division of Texas Instruments Incorporated
National Aeronautics and Space Administration
Nuclear Development Corporation of America
Oak Ridge National Laboratory,
Operated by Union Carbide Corporation
For the U.S. Atomic Energy Commission
Westinghouse Electric Corporation
W. W. Hansen Laboratories of Physics, Stanford Univ.

Write today to Dept. P-49 for illustrated brochure: "HOW MANY JOBS" See for yourself how many jobs GPL Closed-Circuit TV can help you do better.

GPL DIVISION
GENERAL PRECISION, INC.

Pleasantville, New York

Magnetic Domains

This article starts on page 84

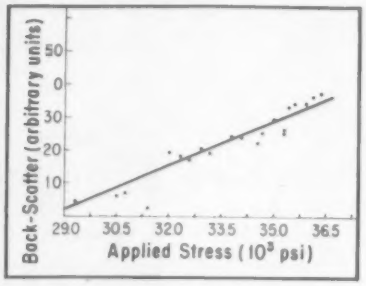


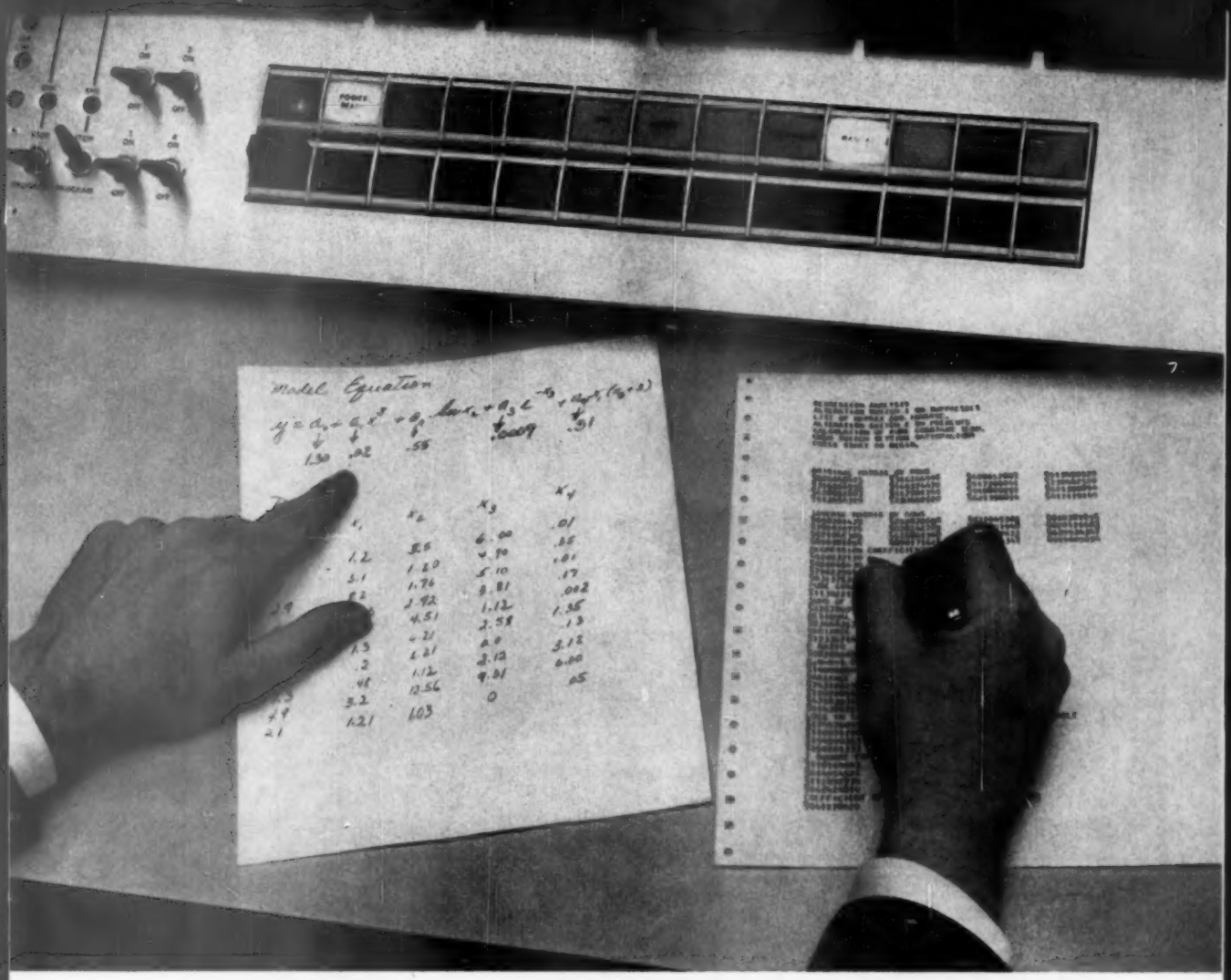
FIG. 2. APPLIED STRESS causes increase in back scatter from demagnetized samples

is a definite relationship between the applied stress and the backscatter—the greater the stress applied to the sample the greater the scattering. This fact explains the difference in scattering between samples of untinned steel of various tempers. A sample with high temper has been cold-worked or stressed more than a sample with a lower temper. Apparently local magnetic fields induced by stressing cause the increase in backscatter observed for the high-temper steels.

Hutchison* has reported changes in the polarization of magnetic domains when a stress is applied to a ferromagnetic material. Our findings, in agreement with Hutchison, suggest that strain-hardening of cold-reduced steel produces weak, discrete magnetic fields in the steel of variable intensity and possibly orientation. These fields are responsible for the variations in back scatter. This hypothesis has received additional support from the observation that steel hot-reduced above its Curie temperature exhibited a more constant and less intense backscatter than cold-reduced steel of similar composition.

Our detector for the backscatter measurements was a standard Tracerlab BG-1 backscatter beta gage. The ionization chamber was approximately 4 in. in diameter and 6 in. high and housed a self-contained Sr^{90} source. The source was shielded from the chamber in such a way that only backscattered beta particles would give a signal. The distance from the sample to the ionization chamber housing was $\frac{5}{8}$ in. We found that the distance could be varied by ± 0.020 in. without causing a significant change in signal.

*T. S. Hutchinson, *Science* **132**, p. 643 (1960).



Want to find the coefficients? It's easy with the new Regression Analysis program for the IBM 1620

Here's another program offered free-of-charge to users of the IBM 1620 Data Processing System. It gives you the kind of results you might expect only from a much more expensive computer. But users of the 1620 know that its low rental cost is deceptive. The 1620 packs *more computing power per cubic inch* than any other computer in its size range.

The Regression Analysis program is a good example. Suppose you want a fit for production purposes. If you employ more than two variables you probably have difficulty visualizing the representation of your data. If linearity is not the case, you must often guess blindly at a polynomial of high degree, accept or reject the fit with something approaching a sixth sense, and either try again or settle for the results you have.

The new Regression Analysis program lets you handle expressions containing up to *24 variables*. If you have the even more complicated task of handling many dependent variables, the program will generate regression coefficients with a maximum number of dependent variables not exceeding one-half the number of independent variables.

This program will also fit non-linear functions and hyper-surfaces. Compare this performance with that of any other computer in the 1620's price range.

A basic 1620 installation rents for just $1600 per month. For details, contact your local IBM Representative.

IBM's 1620 is a compact desk-size computer.

IBM®
DATA PROCESSING

FOR HIGH-TEMPERATURE, HIGH-PRESSURE APPLICATION...

NEW 2 AND 3-WAY CECO VALVES ARE READILY ADAPTABLE TO YOUR REQUIREMENTS!

Fabricated without organic materials, the carbon steel valves pictured here represent a new Chandler Evans valve design which lends itself to a variety of special-purpose applications.

Requirements on this particular assignment were for valves to provide flow of demineralized water up to 400 gpm at temperatures to 600°F. and pressures to 2000 psig, with minimum maintenance for 25-year service. An air-operated actuator is an integral part of each assembly, and an air-supply system and remote control panel complete the package.

Development of valves in this series was facilitated by CECO's high-temperature test loop. CECO engineers accented flexibility in design. The valves can be scaled up or down to suit other flow, temperature or pressure requirements. They can be fabricated from materials compatible with corrosive fluids. They are ideal for remote control installation, using manually or electrically operated selector valves. Pneumatically actuated in present form, they can be adapted for mechanical, hydraulic or electrical actuation.

To discuss your requirements, contact Mr. Harold E. Francis, Nuclear and Industrial Products Manager.

CHANDLER EVANS CORPORATION West Hartford 1, Connecticut

A SUBSIDIARY OF FAIRBANKS WHITNEY CORP.

CECO SYSTEMS CONTROLS

In-Pile Corrosion of an Aluminum Alloy

by NOEL P. SHIELLS, ROBERT O. BOLT and JAMES G. CARROLL
California Research Corp., Richmond, California

We have found massive deposits of $Al_2O_3 \cdot 3H_2O$ on the surface of an inpile experimental facility made of 6061-T6 aluminum (nominal composition: 0.25 w/o Cu, 0.6 Si, 1.0 Mg, 0.25 Cr, 97.9 Al). The shuttle-tube apparatus was exposed to $\sim 1.3 \times 10^{22}$ nvt (neutrons $\geq$ 100 ev) below 150°F in Hole HB-5 of the Materials Testing Reactor. We believe that the most likely source of this corrosion is nitric acid formed in moist air through the radiation-induced fixation of nitrogen from the air. We are not certain that this phenomenon is the cause of the massive corrosion; if it is, it could occur with several metals (iron, nickel, lead, zinc, copper and cobalt) used in reactors (*1–4*). To determine whether the reaction could be a hazard to reactor operation, the mechanism and reaction rates must be studied further.

We used a 20-ft-long shuttle tube in MTR to expose organic compounds in 3 × 1-in.-o.d. capsules to closely controllable temperatures and radiation doses (Fig. 1). When we found it difficult to remove irradiation capsules, we suspected some debris had accumulated in the shuttle tube (clearances were not critical). We unsuccessfully tried to clean the tube using brushes, reamers, trichloroethylene washes and, finally, nitric acid washes. So we removed the shuttle tube from the reactor for close inspection. Figure 1 shows the coating we found on the outside surface of the tube. Figure 2 shows the deposit we found inside the irradiation chamber that was on the inner end of the shuttle tube. Notice the complete absence of deposits in the water-coolant passages (two round holes and three irregular holes in wall). Figure 3 shows the configuration of the irradiation chamber.

A 2-in.-long chunk of the brittle and porous deposit we took from inside the tube read 0.8 r/hr at contact. Analysis by emission spectrometry showed the metal to be mainly aluminum with traces of chromium, cadmium, copper and other metals. X-ray diffraction showed the mass to be $Al_2O_3 \cdot 3H_2O$, as is the coating on the tube exterior.

Shuttle-tube history. During the 17,000 Mwd (~25 fuel cycles) the shuttle tube was in the reactor it was exposed to $\sim 1.3 \times 10^{22}$ n/cm² ($\geq$100 ev) plus a like number of thermal neutrons and associated gamma rays. During this time continuous water cooling kept the irradiation-chamber wall and adjacent parts at $\leq$100°F most of the time (it was never above 150°F). Outlet water remained at ~70°F, having risen 1°F through the shuttle tube. Capsule heat was removed by air whose flow we controlled from the reactor face. Air temperatures ranged from 300 to 900°F, as measured by a thermocouple nesting in a special thermowell in the capsule. Without a capsule in place and with no cooling air flow, the thermocouple usually reached equilibrium at 175°F. Because all other parts in the radiation zone were cooled with water, only the thermocouple, the guide tube and the capsule and its contents were subject to temperature rise.

A small flow of air contacted the inner walls of the carrier tubes and the outer walls of the outside shell at all times because of the continuous reactor vacuum that drew "leakage" air from the reactor face. This air came from inside the reactor building, which is kept scrupulously clean. Additional air from the startup source used for radiation instruments was introduced internally during the intermittent operation of the shuttle tube.

Likely causes. Many possibilities must be considered. The most significant clue is that they occurred internally and externally during exposure to air and radiation. Deposits were heaviest where flux was highest. Thus the corrosion appears to have been induced by radiation. Direct action by oxidizing agents could have caused the corrosion. Both H_2O_2 (a primary product in water radiolysis [*5*]) and ozone (formed when air is irradiated [*6–8*]) corrode aluminum by direct oxidation. Although enough of both are present to cause aluminum oxidation (*9, 10*), reaction rates are not known and mechanisms become speculative. A second possible source of oxidizers might be the host of short- and long-lived products from the radiolysis of air (*7*); these could promote or even catalyze the direct oxidation of aluminum. Probable products would be oxides or hydroxides of aluminum, which would tend to equilibrate to the trihydrate observed. But the most likely corrosion source is the nitric acid formed when moist air is irradiated. Irradiation of the air in the shuttle tube results in nitrogen fixation as oxides (*1*), which normally are passive to aluminum (*9*). But when these combine with the moisture in the air, dilute nitric acid forms, this corrodes aluminum (*9, 11*). The corrosion product is preferentially the nonahydrate; the nitrates of trivalent metals hydrolyze easily (*12*). In this way, the $Al(NO_3)_3 \cdot 9H_2O$ hydrolyzed giving the oxide, Al_2O_3. This compound is hygro-

(*Continued on page 102*)

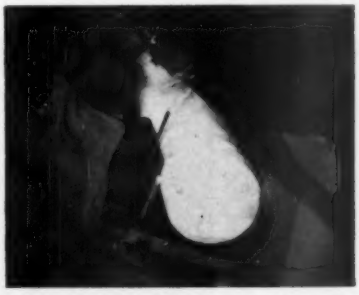


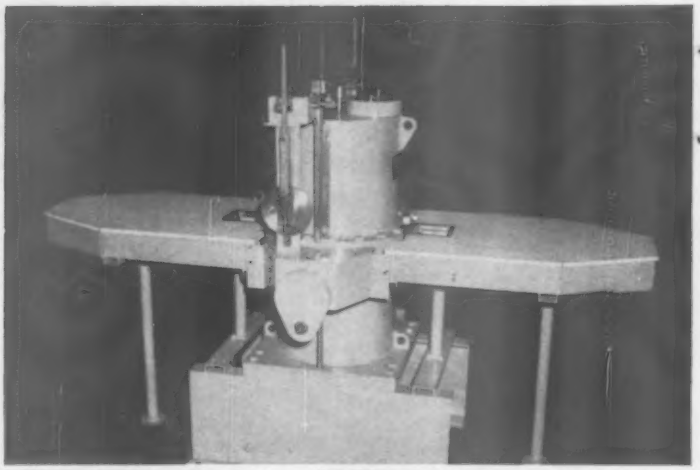
FIG. 1. WHITE COATING ON OUTSIDE surface of shuttle tube is ~1/8 in. thick at inpile end (nearer) and is of nearly negligible thickness at flange ~2 ft back

FIG. 2. HEAVY DEPOSIT INSIDE irradiation chamber obscures capsule rebound plate and air passages at end of chamber, as is shown in sectional cut

National Lead has the Facilities and Abilities to

PRODUCE

your Gamma Shielding whatever its size or complexity



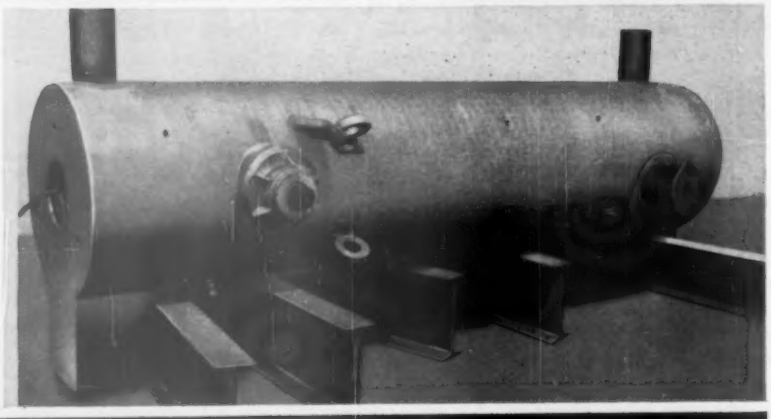
National Lead has the Facilities and Abilities to

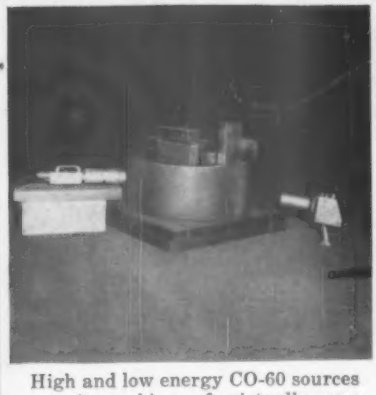
PROVE

your Gamma Shielding for soundness and heat transfer

Our mobile radiation laboratory is completely equipped to test gamma shielding anywhere a truck can travel.

When the job involves lead bonded to steel, copper, aluminum, etc., the completeness of the bond can be tested with our ultrasonic equipment.





High and low energy CO-60 sources permit probing of virtually any thickness of lead shielding.

Small to medium size casks and vessels can be radiographed in our indoor radiation laboratories.

In our outdoor test areas, shieldments can be probed on our gamma scanning variable speed turntable.

You can entrust the fabrication of your gamma shields to National Lead for several reasons: First, you can have the "contract-performance" confidence that derives from dealing with the largest fabricator of lead goods. Second, you can have the convenience and service advantages of dealing with one of the Company's plants located relatively close to your base of operations. Third, you can have the assurance that your job will have the attention of men widely experienced in many phases of nuclear energy—via the Company's own activities in this field. Fourth, your shieldment can be proved "up to specs" before it leaves our custody, by the use of our probing and ultrasonic testing equipment. Or, thanks to our mobile laboratory, the shielding can be tested "on the job."

Lead-pouring capacity, for example, dramatically indicates the scope of National Lead's capabilities. To the best of our knowledge, no gamma shield yet devised could tax the capacity of lead-pouring facilities at several of our plants. Batteries of 70-ton pots, hooked up in series via piping and pumps, assure an inexhaustible supply of molten metal—in one continuous pour.

When you need gamma shielding, whether it be shot, brick, sheet, slab, sleeving and other off-the-shelf forms; or custom casks, vessels and shapes—regular-filled or bonded—get in touch with your nearest National Lead office.

NATIONAL LEAD COMPANY

Atlanta 9, Ga., 451 Bishop St., N.W.
Baltimore 3, Md., 214 W. Henrietta St.
Boston 6, Mass., 800 Albany St.
Chicago 80, Ill., 900 W. 18th St.
Cincinnati 3, Ohio, 659 Freeman Ave.
Cleveland 13, Ohio, 1776 Columbus Rd.
Dallas 16, Texas, 1000 Sargent Rd.
Denver 5, Colo., 2945 Blake St.
Depew, N.Y., 3241 Walden Ave.
Detroit 11, Mich., 3501 Griffin St.
Houston 1, Texas, 1417 Hardy St.
Kansas City 7, Mo., 1406 W. 13th St.
Milwaukee 3, Wisc., 808 N. Third St.
New Orleans 12, La., 516 Tchoupitoulas St.
Omaha 7, Neb., 2810 "A" St.
Perth Amboy, N.J., 1050 State St.
Pittsburgh 12, Pa., 1376 River Ave.
St. Louis 1, Mo., 722 Chestnut St.
St. Louis Park 26, Minn., 3650 Hampshire Ave.

MORRIS P. KIRK & SON, INC.
(Subsidiary of National Lead Company)

Emeryville 8, Calif., 4050 Horton St.
Fresno, Calif., 845 Topeka Ave.
Los Angeles 23, Calif., 2700 S. Indiana St.
Phoenix, Ariz., 1102 W. Watkins St.
Portland 10, Ore., 5909 N.W. 61st Ave.
Salt Lake City 4, Utah, 977 S. Sixth West St.
Seattle 4, Wash., 3614 Airport Way
Spokane 2, Wash., E. 41 Gray Ave.

NATIONAL LEAD COMPANY GAMMA SHIELDING

National Lead Company

General Offices: 111 Broadway, New York 6, New York • Branches in all principal cities

scopic and tends to form $Al_2O_3 \cdot 3H_2O$.

The water supply needed for the reactions postulated is not clear cut. There probably was some water in both the house air pulled in by the pile vacumm and also in the instrument air used during capsule maneuvers. However, during internal cleaning operations we removed acid by rinsing with water; we conducted three cleaning operations about a month apart. We detected some water in the system a day or more after each cleaning, so adequate water was inside the tubes for these reactions. To cause the corrosion on the outside of the shuttle tube, the air pulled in by the vacuum must have been moist enough to promote the reaction.

Unlikely Causes

We have considered other possible causes of these deposits: debris accumulation, overheating, excessive corrosion, reactions with residual cleaning solutions and galvanic corrosion.

Debris accumulation. Normal operation of the capsules and cleaning might have caused debris to enter the tubes. But the nature of the internal debris and the extent of the external corrosion eliminate this explanation. Silica dusts sucked into the equipment because of the continuous reactor vacuum (~½ psi below atmospheric) might have accumulated gradually, but the deposits were alumina.

Overheating. Gamma heating might have raised temperatures enough to cause local melting (m.p. ≈ 1,220°F) if the shuttle-tube coolant flow had been cut off inadvertently; but we found no evidence of melting even in internal parts. Even after many days' exposure at 1,110°F an oxide layer only ~0.0002 cm thick forms (*9*).

Excessive corrosion. Although aluminum will corrode in water at 500°F (*13, 14*), aluminum alloys have been used extensively in water-cooled reactors and there has been little evidence of corrosion problems due to irradiation (*6, 10, 15–18*). There is some opinion that irradiation improves the corrosion resistance of aluminum in water (*16, 19*). If much corrosion had occurred we would have seen evidence of it, at least in regions of low water velocity, and we would have detected an increased radioactivity level in the effluent water stream.

Residual cleaning solutions. We used trichloroethylene in cleaning operations. But chlorinate hydrocarbons do not corrode aluminum in the absence of water; and in the presence of water chloride ions promote pitting, not general corrosion (*6*). Only a very small amount of solvent could have been present, especially outside the tube.

Galvanic corrosion. There were two small pieces of stainless steel in the irradiation chamber; in solution, aluminum would be anodic to stainless steel and tend to corrode (*6, 20*), but the galvanic corrosion currents would be small (*21*). Further, stainless gives "anodic protection" to aluminum be-

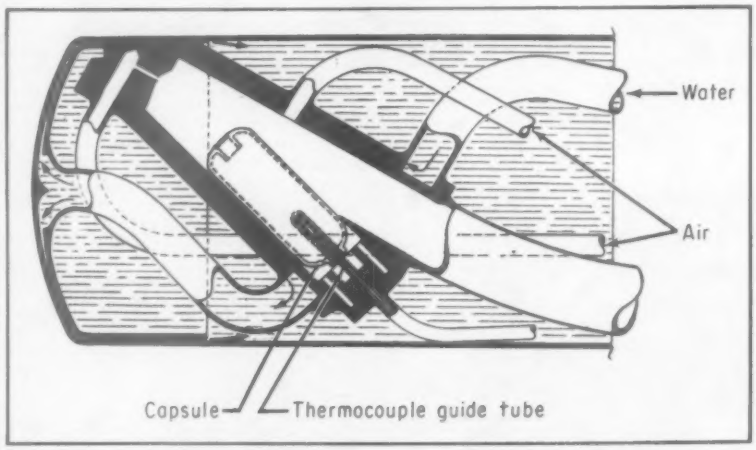


FIG. 3. IRRADIATION CHAMBER for exposing capsule was heart of shuttle tube. Capsule was heated mainly by reactor gammas of ~½ watt/gm. Shuttle tube in reactor exposure zone was made of 6061-T6 aluminum except for capsule rebound plate (not shown) and thermocouple guide tube, which were stainless steel

VITREOSIL®
PURE FUSED QUARTZ
FOR USE IN PRODUCTION OF SEMI-CONDUCTOR METALS...

Where you produce such metals as germanium and silicon, VITREOSIL is ideal for use. For special requirements or special problems, write us your requirements. **Now available Quartz to metal seals.** See our ad in **Chemical Engineering, Electronic Engineers Master & Electronic Designers' Catalogues.**

SPECTROSIL®
FOR HYPER-PURITY IN SEMI-CONDUCTOR WORK
Unique Transmission characteristics

PURITY—purest form of **fused silica**
TRANSPARENCY—unique optical properties
HOMOGENEITY—**completely** homogeneous and free from granularity
AVAILABILITY—**block material** for lenses, prisms, etc; **rod, fiber, wool; hollow ware** as tubing, crucibles, and special apparatus.

Write for complete illustrated catalog.

THERMAL AMERICAN FUSED QUARTZ CO., INC.
18-20 Salem St., Dover, N. J.

cause it promotes general corrosion rather than localized pitting (*6*). If galvanic action occurred in the shuttle tube, aluminum corrosion should have been small because of the large anode surface (on a mass basis, there was ~800 times more aluminum then stainless steel). Very likely the aluminum-stainless junctures were never immersed, so any galvanic actions would occur chiefly at the juncture. Also, galvanic corrosion would be confined to the irradiation chamber because the outer shell was made entirely of aluminum alloy.

* * *

We gratefully acknowledge the assistance of F. N. Fossati and J. W. Unverferth of California Research Corp. in all problems pertaining to the shuttle tube. We also wish to thank the following personnel of Phillips Petroleum Co: R. B. Van Sice for liaison and guidance, J. Ronsick for hot-cell operations and E. Turk for discussion of the corrosion problem. This research activity was sponsored in part by the U. S. Atomic Energy Commission under Contract AT(04-3)-248.

BIBLIOGRAPHY

1. W. Primak, L. H. Fuchs, NUCLEONICS **13**, No. 38 (1955)
2. A. V. Byalobzheskii, *Zhur. Fiz. Khim.* **33**, 1256 (1959) (*Nucl. Science Abs.* 22492, vol. 13)
3. A. V. Byalobzheskii, *Doklady Akad, Nauk, SSR* **119**, No. 3, 515 (March 1958) (*Nucl. Science Abs.* 424, vol. 13)
4. J. V. Shatalov, V. A. Nikitins in "Proceedings of Second International Conference on Peaceful Uses of Atomic Energy," vol. 7, p. 284, (United Nations, Geneva, 1958)
5. J. Wright, et al. in "Proceedings of Second International Conference on Peaceful Uses of Atomic Energy," vol. 7, p. 560 (United Nations, Geneva, 1958)
6. A. L. Medin, R. J. Clark, APAE-Memo 44 (Alco Products, Schenectady, 1956)
7. P. Harteck, S. Dondes in "Proceedings of Second International Conference on Peaceful Uses of Atomic Energy," vol. 29, p. 415 (United Nations, Geneva, 1958)
8. J. E. Douglas, L. C. Bratt, E. M. Kinderman, *J. Chem. Phys.* **31**, No. 5, 1416 (1959)
9. J. W. Mellor, "A Comprehensive Treatise on, Inorganic and Theoretical Chemistry," vol. 5, p. 204–263 (Longmans, Green and Co., London, 1924)
10. M. H. Bartz in "Proceedings of Second International Conference on Peaceful Uses of Atomic Energy," vol. 5, p. 467 (United Nations, Geneva, 1958)
11. G. A. Nelson. Corrosion data survey, p. N-2, N-3 (Shell Development Co., Emeryville, Calif., 1960)
12. P. C. L. Thorne, E. R. Roberts, "Fritz Ephraim-Inorganic Chemistry," 6th ed-rev., p. 726 (Oliver and Boyd, Ltd., London, 1954)
13. M. H. Brown, R. H. Brown, W. W. Binger, Aluminum alloys for handling high temperature water, presented at 16th Annual Conf. Natl. Assoc. Corrosion Engrs. (Dallas, Texas, March 1960)
14. E. D. Verink, private communication (Aluminum Company of America, Pittsburgh, Pa., September 1960)
15. B. C. Allen, et al., REIC-5 (Battelle Memorial Institute, 1958)
16. J. E. Draley, et al. in "Proceedings of Second International Conference on Peaceful Uses of Atomic Energy," vol. 5, p. 113 (United Nations, Geneva, 1958)
17. F. Hittman, O. A. Kuhl, BNL-2257 (1955)
18. M. T. Simnad in "Effects of Radiation on Materials," p. 127, J. J. Harwood, ed. (Reinhold Publishing Company, New York, 1958)
19. H. H. Hausner, *Prod. Eng.* **28**, No. 4, 169 (1957)
20. R. L. Horst, *Ind. Eng. Chem.* **48**, No. 9, 1696 (1956)
21. H. P. Goddard. The corrosion behavior of aluminum, *Corrosion* **11**, No. 12, 542 (1955)

7-C-12 Evaporator system, 360 liter/sec. capacity; available with glass or metal chamber

Ultek ELECTRONIC high-vacuum SYSTEMS

clean vacuum—no fluids, no contaminants

high vacuum—10^{-5} through 10^{-9} mm Hg and below, chamber volumes from 0.001 to 100 cubic feet

low-cost operation — UlteVac ionic pumps need minimum maintenance, operate unattended for months
System completely self-contained and movable
No water lines or plumbing connections
Requires only an AC outlet

high-vacuum applications . . .

- vacuum tube processing
- thin film deposition
- space simulation
- environmental testing
- general physics research

complete vacuum line . . .

- standard and custom systems, with pumps from 5 to 2000 liters/sec.
- sorption roughing pumps
- metal-sealed fittings
- high-vacuum valves
- ambient foreline traps
- vacuum chamber feed-throughs and view ports

Write Today —
FREE Reprint of technical article, "Ionic Vacuum Pumps," by Dr. Lewis D. Hall

ULTEK CORP.
920-N Commercial St.• Palo Alto, Calif.• DA 1-4117

ULTEK SALES ENGINEERING OFFICES:
BOSTON • CLEVELAND • PHILADELPHIA

Ultek vacuum station designed for experimental tube processing

Hallam Radiation Facility Might Be World's Cheapest

When the Hallam, Nebraska, Nuclear Power Facility goes critical soon, it will have available the piping connections and an uncluttered site for a facility that could probably produce the world's cheapest radiation processing. Preliminary cost estimates for a plant that would use radioactive sodium from the primary coolant system indicate that products could be irradiated at ~1¢/megarad-lb (*1*) as compared with 1.7¢/megarad-lb at Wantage, England (*2*). Directors of Consumers' Public Power District, operator of Hallam, have established a policy that primary sodium will be made available at the smallest possible incremental cost (*3*). Thus costs of the radiation facility would not be used to decrease electric-power costs, nor would electric-power revenues decrease radiation costs.

Although Consumers Public Power, with fundamental responsibility for power production, will not enter the radiation-processing industry, it will make every effort to cooperate and assist any one who will.

Site Is Available

The radiation facility can be installed at any time in the future without significant downtime for the operating power plant. The reactor design includes all piping changes, wall penetrations and other requirements in the nuclear facility, and Consumers has been successful in keeping the area around the proposed facility open for future construction.

A plan developed for the facility (*1*) would have an underground chamber, five 20-ft × 12-ft × 4-in. plaques and five separate conveyors to handle products ranging from grain in bulk to heavy packages. Dose rates between plaques would be 2.5–3 × 10^5 r/hr, and conveyor speeds would be adjustable. An automatic dose controller would change the speeds to compensate for changes in sodium specific activity.

Conveyor System

The five conveyors would be driven by power units outside the irradiation chamber through shafts and cams. Each would be independent of the others, and all could be operated simultaneously, each adjusted for a different dose.

A special tray conveyor, a trolley type, could carry bags of potatoes as heavy as 100 lb or packages spaced 2 ft apart. Capacity would be 1,680 megarad-lb/hr. Two smaller basket conveyors, also of trolley type, are designed for packages, cans or boxes up to 6 × 16 × 21 in. in size. Each would have a capacity of 1,520 megarad-lb/hr. A flat chain conveyor would be 7 in. wide and carry cans and boxes of various dimensions. Loaded at 25 lb/ft, it would have a capacity of 760 megarad-lb/hr.

Bulk material such as grain would go into a hopper in the top of the radiation cell. Then two screw-type conveyors would carry it down the length of the plaques and back again, discharging it into an elevator that would bring it back up to ground level. Capacity for wheat would be 335 megarad-lb/hr.

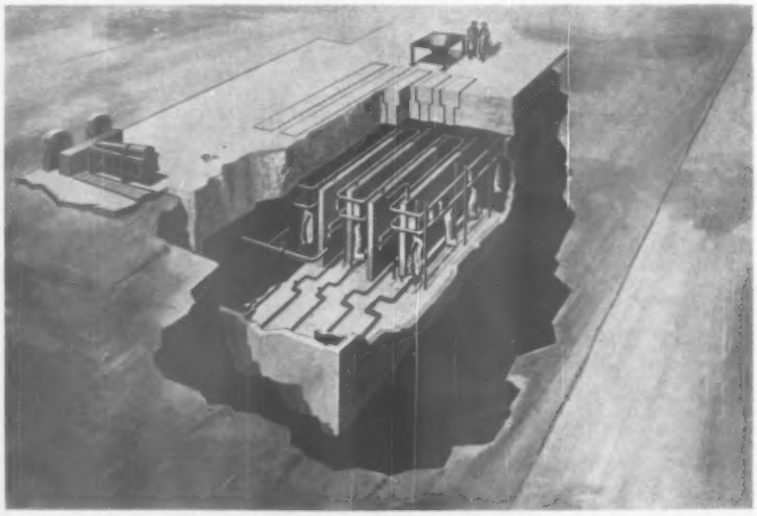
Sodium Source

Primary sodium is a good radiation source. Originally it consists entirely of Na^{23}, which has a 0.53-barn cross section for thermal-neutron capture and production of Na^{24}. Na^{24} emits two gamma rays (2.76 and 1.38 Mev) in essentially all of its disintegrations. Its 15.1-hr half-life is short enough to produce many disintegrations in a radiation source and long enough that one need not pump it rapidly to supply the source. Another advantage is that source strength will change only slowly with reactor power.

Plaques and conveyors would be housed in a 77 × 46.5-ft irradiation chamber along with an electromagnetic pump and a drain tank. Removable blocks in the 7-ft-thick roof would allow access for machinery. Access for personnel and conveyors would be along a 111-ft slanting tunnel.

For removal of heat escaping from the 600°F sodium as well as that generated by radioactive disintegrations the design offers a choice between a ventilation system and a refrigeration system. Ventilation alone would keep the temperature at about ambient; refrigeration would offer temperatures down to 20°F.

When the radiation plaques are to be filled they will be flushed first with helium so that sodium need not come in contact with oxygen. To assure sodium flow and prevent thermal shock, electrical heaters will bring the whole



IRRADIATION FACILITY WITH HALLAM REACTOR would use primary sodium in five plaques, among which would run five independent conveyors for packages and bulk material

system to 560°F. Sodium to fill the plaques will come from the primary filling tanks, driven through five lines by primary-system service pumps.

Once the plaques are filled, the sodium in them will be circulated at 100 gpm by a 3-in. electromagnetic pump; a total change of content will require 28 min.

Safety

The principal hazard one would have to guard against would be sodium leakage, and safety provisions include means to detect the leakage, vent any resulting radioactive gases and put out a possible sodium fire.

All sodium piping would be double walled with nitrogen circulating in the annulus. Monitors will watch the nitrogen for radioactivity due to escaping sodium; if they find any, the nitrogen will be removed from the facility and vented through a filter bank and the reactor stack. Meanwhile an external leak-detection system will have detectors every 20 ft and at all low points.

In the event of a sodium fire a dry-chemical fire-suppression system would flood the irradiation chamber with a mixture of finely powdered anydrous metal chlorides and metal. The system would offer fire protection for ~1 hr; meanwhile the facility would be drained of sodium in ~4 min.

Costs

Consumers Public Power feels that the proposed facility would give smaller radiation costs than any facility now planned since the only loss to power generation is the extremely small heat loss by sodium circulating in the irradiation facility. The estimated processing cost is based on a requirement for refrigeration and a conveyor system capable of handling a large variety of products. Elimination of the flexibility and adjustment of a conservative plant factor (80%) for the power plant would improve the economics.

Costs are based on an over-all cost of ~$1 million for the facility ($770,000 for a ventilated facility; $120,000 for conveyors and controls; $125,000 for refrigeration equipment), $396/day for manpower and electricity and a 15% charge for invested capital.

BIBLIOGRAPHY

1. D. S. Thompson et al, NAA-SR-3260 (January 31, 1959)
2. J. Tunstall, NUCLEONICS **18**, No. 2, 100 (1960)
3. Private communications from E. Jones to R. H. Ellis, Jr., May 19, 1960 and June 8, 1961

High Voltage Engineering Corporation . . .

"CHARGED PARTICLES"

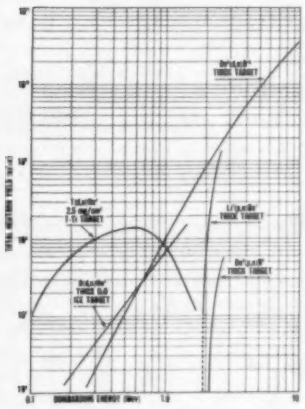
Accelerators on the Research Frontier

We keep rewriting copy on this theme, and properly so. The needs of science for charged particles in nuclear structure research continue to create dynamic interest in Van de Graaff and microwave linear accelerators, and intensive development is leading to performance in energy and current that could not be considered even a short while ago. The uses for higher energy, greater intensity, and more exacting specifications of stability and pulsing are not clearly known, but consideration of attainable accelerator performance may stimulate action on research programs lying dormant for lack of appropriate apparatus. The advanced characteristics here outlined can be contemplated now, due to recent technical advances in the design of accelerator components.

Energy

The capability of the Tandem Van de Graaff to reach into the range well above 20 Mev with precisely stabilized positive ions is a reality. Currents will be more than adequate for useful nuclear structure research.

New linacs of proven design extend high pulsed currents of electron beams to hundreds of Mev. They open up great areas of neutron physics and monoenergetic gamma work for physicists. The high power capabilities are now matched by sophisticated analyzing, deflecting and collimating systems which are as important to experimental work as the linacs themselves.

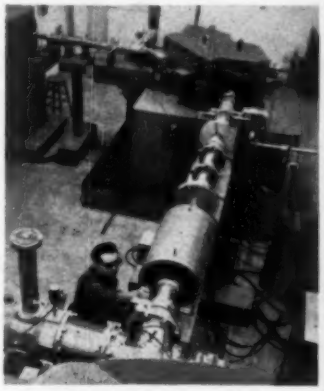


Neutron yields versus bombarding energy.

Intensity

Electron or ion-beam currents in the one-ampere range at a few Mev can now be considered seriously. A specially-designed accelerator has shown excellent life performance at 1 Mev and 20 milliamperes of electrons as part of High Voltage Engineering's continuing test program to reduce the cost of ionizing radiation energy at high power levels.

The x-ray and neutron outputs from these beams are indeed heroic: *X-rays — millions of rads per minute at a few centimeters distance. Neutrons — 10^{13} neutrons per second from a "point" source.*



High-energy end of 12-Mev Tandem Van de Graaff Accelerator.
Photo courtesy University of Wisconsin

Pulsing

New techniques enable Van de Graaffs to be pulsed from a few nanoseconds up to a millisecond. Instantaneous intensities as described above make feasible the consideration of hundreds of rads per pulse, or more than 10^{11} neutrons per burst.

Energy Stability

It is now possible to consider stabilizing systems to a limit imposed primarily by the thermal motion of nuclear targets. With little effort, continuous particle-energy stabilities of a few tens of electron-volts can be provided.

Among the research fields in which these particle-accelerator characteristics may make a considerable contribution are: *nuclear physics, biology, solid-state, radiation damage, plasma physics, ignition of thermonuclear systems, and space-environment studies.*

Physicists and radiation chemists at High Voltage Engineering are prepared to explore on an individual basis, long-range and immediate research problems that could utilize our accelerator systems.

This is part of a series of which reprints are available on request to: Technical Sales Department.

HIGH VOLTAGE ENGINEERING CORPORATION
BURLINGTON, MASSACHUSETTS, U.S.A.
●
APPLIED RADIATION CORPORATION
●
HIGH VOLTAGE ENGINEERING (EUROPA) N.V.

Reliability from experience with over 250 accelerators in the field

Molecular Dissociation in Charge-Transfer Reactions

by VLADIMIR CERMÁK and ZDENEK HERMAN

Institute of Physical Chemistry, Czechoslovak Academy of Sciences, Prague, Czechoslovakia

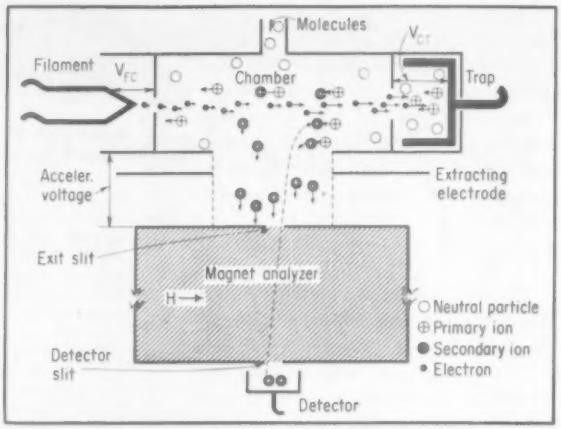


FIG. 1. MASS SPECTRUM ANALYSIS of secondary ions created in charge-transfer collisions with monoatomic primary ions. Voltages in ion source of conventional mass spectrometer are adjusted so that primary ions are created only in region of trap and charge-transfer reactions occur in ion source chamber

By modifying an ordinary mass spectrometer we have been able to study the decomposition of polyatomic molecules excited by charge-transfer reactions. In such reactions a monoatomic ion transfers its positive charge to a neutral molecule (i.e., takes an electron from the molecule) and in so doing leaves the newly formed molecular ion in an excited state. The excited molecule then decomposes to form a lighter ion; this can happen in a variety of ways. For instance, we have observed that excited propane ions ($C_3H_8^+$) yield 8 ionic species ranging from $C_3H_7^+$ down to $C_3H_2^+$. Our measurements of the relative abundances of decomposition species indicate that the decomposition process of excited polyatomic ions is independent of how the ions are excited—whether by electron bombardment, photon bombardment or charge transfer. This similarity has a number of consequences: On the one hand it might be possible by extrapolating the charge-transfer results to make predictions about the reaction rates of gases undergoing radiochemical reactions and on the other hand it might be possible to check the fundamental assumptions of the statistical theory of mass spectra. In these studies the technique of excitation by charge-transfer reactions has an advantage over other excitation methods in that the excitation energy is precisely known —it is equal to the recombination energy of the atomic ion minus the ionization energy of the excited molecule.

Charge Transfer Reactions

Among the different types of charge transfer (electron exchange) reactions

$$A^+ + A = A + A^+ \quad (1)$$
$$A^+ + B = A + B^+ \quad (2)$$
$$A^+ + BCD = A + BC^+ + D \quad (3)$$

(where A and B may be atomic or molecular particles), type 3 reactions are particularly important because

- of their role as elementary ionic reactions in radiation chemistry, reactions in flames, in gaseous discharges etc. This is clearly demonstrated by the number of recent papers dealing with the effects on the radiolysis products in gaseous hydrocarbons (*1–5*) of the admixture of inert gases
- such reactions are closely connected with the mechanism of dissociation and fragmentation of excited molecular ions, the knowledge of which is important in interpreting the results of radiolysis (*G* values, etc.) using mass spectra of radiolysed substances
- these reactions represent an extension of the field of the charge-transfer reactions limited, until recently, to the reactions between atomic or diatomic particles.

Studies of atomic or diatomic systems (*6*) have shown that the collision cross sections are of the order 10^{-14}–

Charge-Transfer Mass Spectra for Methane and Ethylene Mixed with A, Kr and Xe*

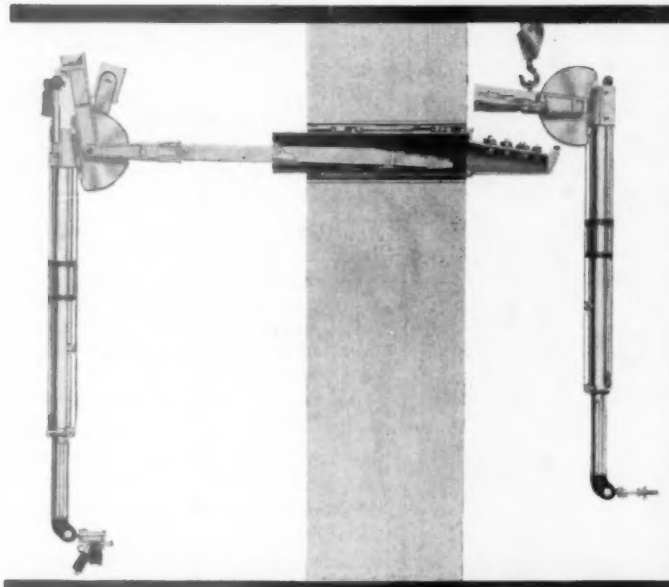
Secondary ion	*Relative abundance of secondary ions (%)*		
	A (*15.75 ev* / *15.95 ev*)‡	*Kr* (*14.0 ev* / *14.67 ev*)‡	*Xe* (*12.15 ev* / *13.44 ev*)‡
Methane			
CH_4^+ (13.12 v)†	2.0	64.5	97.0
CH_3^+ (14.31 v)†	79.0	35.0	2.5
CH_2^+ (15.6 v)†	19.0	0.5	0.5
Ethylene			
$C_2H_4^+$ (10.17 v)†	3.0	2.5	68.0
$C_2H_3^+$ (14.0 v)†	76.0	58.5	9.5
$C_2H_2^+$ (13.5 v)†	21.0	39.0	22.5

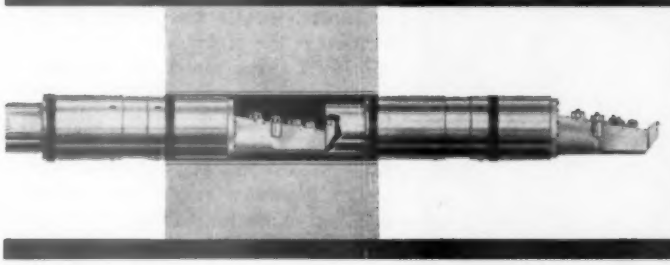
* V_{FC} = 5 v, V_{CT} = 25 v. ‡ recombination energies

† appearance potential—energy required to split up molecule into ion and neutral fragments (as determined by mass spectrometry)

NEW . . . for high-level alpha-gamma hot cells—for handling pyrophoric, highly toxic gaseous or airborne particulate materials—wherever complete atmospheric control, prevention of dissemination by explosion or other accident is essential . . .

complete containment is provided by central research model A sealed manipulators





Sensitive and reliable, Model A manipulators are designed for dextrous, positive control and complete containment with shielded enclosures.

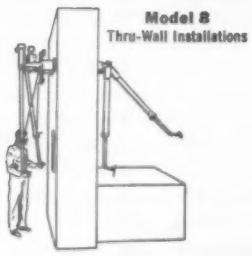
CONSIDER THESE IMPORTANT FEATURES:

SEALS—Double rotary mechanical seals between master and slave mechanisms insure reliability. Space between seals may be pressurized to monitor seal integrity. One seal is always operative even when changing seal tubes. "Push-thru" seal-tube replacement technique does not require complete wall port opening. Seal-tube features mean that all contaminated assemblies remain inside cell for disposal or decontamination and need never be brought out to the operating face.

OPERATION—Careful counterbalancing, reduction of mass, friction and lost motion make forces in the ounce range sufficient to initiate all motions. Easily handles 20-pound load per arm. Bilateral drive and force reflecting design characteristics give remarkable "sense of feel," reducing training time to a minimum.

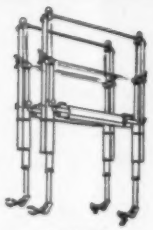
MAINTENANCE—Three standard, interchangeable subassemblies: master arm, slave arm, and seal tube, simplify maintenance. A crane and simple fixture are sufficient for remote connection or removal of slave arm. Alignment pins assure positive slave arm positioning. All slave-end motions lock at disengagement for easy relocation.

CENTRAL RESEARCH . . . MANIPULATORS FOR EVERY NEED



Model 8
Thru-Wall Installations

Model 7
Restricted Space Installations



Model 4
Over-Wall Installations

Model B
Canal Manipulator

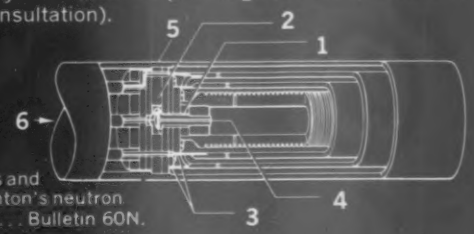
For further information write:

Central Research
laboratories, inc.
Red Wing, Minnesota, Dept. 110

WHY LIONEL* NEUTRON CHAMBERS CAN STAND UP TO HEAT, VIBRATION AND SHOCK

You can—now—integrate the latest Anton ionization and fission chamber developments into your reactor instrumentation. Operation to 300°C is available. Anton chambers meet requirements of Mil-Std-167 and Mil-S-901 for vibration and shock.

1—and **2**—Anton UNIT-MOUNT fixes the chamber elements rigidly between high temperature ceramics. The self aligning UNIT-MOUNT prevents any movement of precisely positioned concentric elements with respect to each other. **3**—Exact electrode spacing maintained by precision ground ceramic spacers. **4**—An unobstructed exhaust port is provided. **5**—2-S Aluminum outer envelope. **6**—Connector end not shown, but a variety of connectors (watertight, welded, hermetic, etc., available upon consultation).



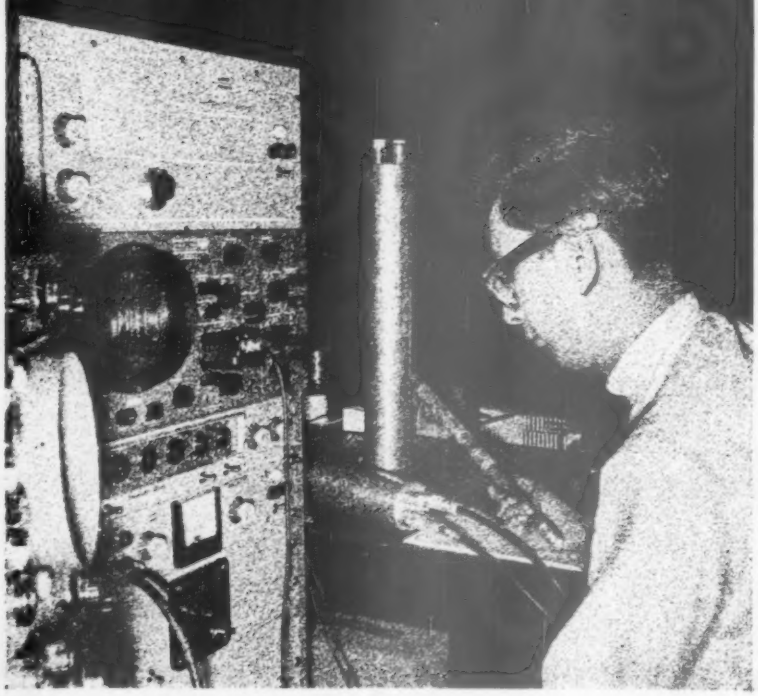
Write for free design facts and operational data about Anton's neutron chambers and detectors . . . Bulletin 60N.

LIONEL ELECTRONIC LABORATORIES

*Formerly Anton Electronic Laboratories, Inc.

1226 FLUSHING AVE., B'KLYN 37, N. Y.

A DIVISION OF THE LIONEL CORPORATION



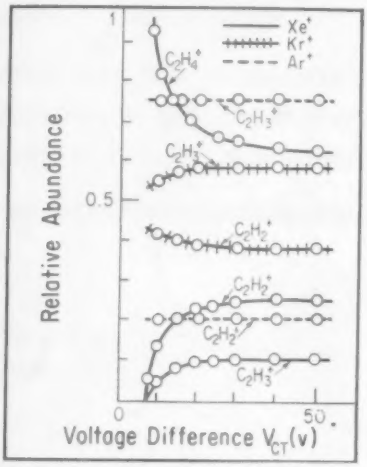


FIG. 2. SECONDARY ION ABUNDANCE may depend on V_{CT} if primary ion has doublet ground state and primary-ion kinetic energy is converted in part to internal energy of molecular ion

10^{-15} cm². The exact value depends on the excitation energy of the reaction (the difference between the recombination energy of the primary ion and ionization potential of the neutral particle) and on the relative velocity of both particles. It was verified many times that the probability of electron transfer between mono and diatomic particles increases as both the excitation energy and the relative velocity decreases. This result is called the resonance rule and applies here as well as for excitation energy transfer in collisions of neutral particles.

The earlier studies of the cross sections of inelastic collisions producing dissociation of secondary charged particles did not include mass analysis of the products. In 1953 Lindholm for the first time included these measurements in work on the charge-transfer reactions of preselected atomic or molecular ions of different recombination energies with molecules such as N_2, CO, H_2O, CO_2, NH_3, N_2O, H_2S, CH_4 and C_2H_5OH (*7–9*). A little later Talroze began his work on charge-transfer reactions of polyatomic molecules (*10, 11*).

In contrast to the simpler atomic and diatomic reactions, the task of investigation for the dissociative charge-transfer reactions is to measure not only the total inelastic collision cross sections and their velocity dependence but also

the relative abundances of the various secondary ions and especially how the abundances vary with excitation energy. Mass spectrometrists refer to plots of abundance measurements such as these as the "breakdown curves" of the excited molecular ion in question.

According to the statistical theory of mass spectra the decomposition proceeds through a number of competitive and successive reactions (*12*, *13*), each of which requires a definite activation energy. To further understanding of excited-ion fragmentation it is necessary to know the relation between excitation energy and reaction rate for the competing processes. Whereas in electron bombardment studies the excitation energy transferred cannot be accurately determined because the scattering angles and energies of primary and secondary electrons are not known, in the charge-transfer reactions the energy transferred to molecular ions can be determined and equals the difference between the primary-ion recombination energy and the ionization energy of the molecule. Given the breakdown curves and the decomposition reactions one can calculate the rate constants and compare them with theoretical values.

One limitation of data gained from mass spectrometers of the Nier type (*15*) is that the data refer to the decomposition state of molecular ions about 10^{-5} sec after the moment of their formation in the ion source whereas in radiation chemistry of gases the time between two collisions (at a pressure of about 100 mmHg) is of the order 10^{-10} sec. Nevertheless, once the breakdown curves have been determined and the rate constants of the decomposition reactions calculated, one can extrapolate the decomposition pattern to the much shorter reaction times of interest in radiation chemistry, provided that a plausible assumption is made about the distribution of excitation energy transferred from the ionizing radiation.

Experimental Technique

The studies of dissociative charge-transfer reactions have involved relatively complicated spectrometer systems consisting of a mass selector of primary ions, a mass analyser of secondary ions and a collision chamber between them (*7*, *10*). We have found, however, that valuable data can be obtained with an ordinary mass spectrometer after a minor change in the ionization conditions within the ion source is made. [Melton (*14*) recently reported the use of a mass spectrometer for the charge transfer studies but his technique is different (alpha particle mass spectrometer).]

In the usual mass spectrometer arrangement the atoms and molecules entering the ionization chamber of the ion source are ionized by electrons of energies as high as 100 ev. The ions so formed are extracted, accelerated and mass analyzed. During their time of residence in the ionization region some of them undergo collisions with uncharged molecules. In these collisions charge-transfer may take place, leading to the formation of slow secondary ions. However, these ions acquire the same energy as they pass through the ion source as the primary ions formed by electron impact; hence, mass analysis alone will not distinguish the secondary ions from the primary ions.

But suppose the usual arrangement is altered as in Fig. 1 so that the voltage difference between the filament and the chamber is no longer enough to accelerate electrons to the point where they can ionize. In this arrangement the

HYDRAULIC CONTROL ROD DRIVE FOR N. S. SAVANNAH

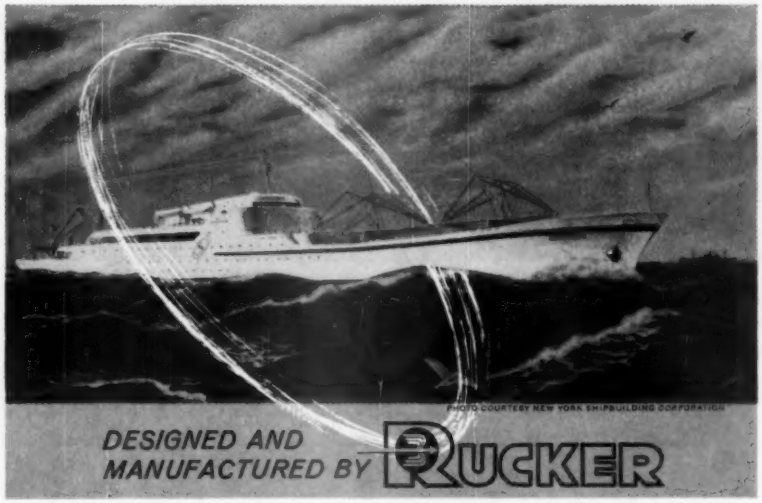


PHOTO COURTESY NEW YORK SHIPBUILDING CORPORATION

DESIGNED AND MANUFACTURED BY RUCKER

The Rucker Scram and Monitoring system maintains an even balance of the N. S. Savannah's reactor, reduces load on the drive mechanism system, assures instantaneous shutdown, and automatically activates reserve power systems.

The Rucker Company offers unparalleled experience in the design and manufacture of electro-hydraulically actuated reactor control rod drive systems for extreme reliability, unequalled response time achievements of 25 milliseconds and less, stored energy, minimum maintenance in hot areas, and positive monitoring from remote locations.

When your problem involves fluidynamic power, you can rely on Rucker . . . a leader in hydraulics and in power and control systems since 1941.

THE RUCKER COMPANY
4700 San Pablo Avenue • OLympic 3-5221 • Oakland 8, California
LOS ANGELES • OAKLAND • PORTLAND • SEATTLE

Other Shim and Scram Systems built by Rucker for Hanford and Indian Point

BERYLLIA CERAMICS ARE BETTER WITH *MINOX* *

Production proven Minox has all the necessary constants that will cut production costs for hot and cold pressings and give superior extrusions, all at lower cost. Prompt delivery assured on three basic grades of Minox ranging in purity to 99.98+%.

A complete line of beryllium compounds including liquid nitrate is available NOW.

WRITE FOR DETAILED INFORMATION

*Trade name for beryllium oxide produced by Mincon.

mincon

MINERAL CONCENTRATES & CHEMICAL CO., INC.
SUITE 1430, FIRST NATIONAL BANK • DENVER 2, COLORADO
PHONE 266-0867 • CABLE: MINCON, DENVER

bombarding electrons must experience the additional acceleration provided by the voltage difference between the chamber and the trap before they are capable of ionization. Hence all the primary ions will be formed in the region of the trap. Positive ions formed in this latter region will move toward the chamber where they collide with neutral molecules. Many of the secondary ions formed in these collisions (through charge transfer and dissociative charge-transfer reactions) will be drawn out of the chamber by the extracting electrode into the magnetic analyzer. This is not so for primary ions; their high velocity in the direction parallel to the slit prevents them leaving the chamber. Similarly those secondary ions cannot be detected that have velocities in this direction corresponding to kinetic energies of a few tenths to a few thousandths of a electron volt depending on the length of the exit and collector slits.

By modifying the ionizing conditions in this way we obtain a new mass spectrum—a secondary mass spectrum or charge-transfer mass spectrum—that belongs to secondary ions produced by collisions of molecules with positive ions and is free of measurable contamination by the primary ions. The charge-transfer mass spectrum can be studied for one gas only or for a mixture of two gases, one of which produces primary ions that afterward collide with their own parent molecules and with the molecules of the second gas. The primary ion current is unresolved and in a single gas would consist of parent ions together with ions of lower mass formed by fragmentation processes. One can obtain primary ions of a unique mass-to-charge ratio simply by using an inert gas as the primary-ion source and keeping the energy of electrons in the region of the trap below the value necessary to form doubly charged ions. With the secondary gas present in dilute concentration, these secondary ions will be formed exclusively by charge-transfer reactions with the monoatomic primary ions. One can vary the excitation energy by repeating the experiment with different inert gases; we used Xe, Kr, Ar and Ne.

The method has a certain drawback in that the absolute charge-transfer cross sections and their dependence on

For the latest reactor construction news . . . read NUCLEONICS WEEK.

The only way you can evaluate NUCLEONICS WEEK is by reading it. Write for a 4-week complimentary subscription.

Make a date this week with . . .

NUCLEONICS WEEK 330 WEST 42nd ST., NEW YORK 36, N.Y.

These securities are not being offered for sale, but have been privately placed through the undersigned. This announcement appears only as a matter of record.

$450,000

NUCLEAR INDUSTRIES INC.
(Valley Stream, Long Island)

Common Stock

Arrangements for the private placement of this initial financing were conducted through the undersigned.

JOHN SCHUSS & CO. A. G. EDWARDS & SONS

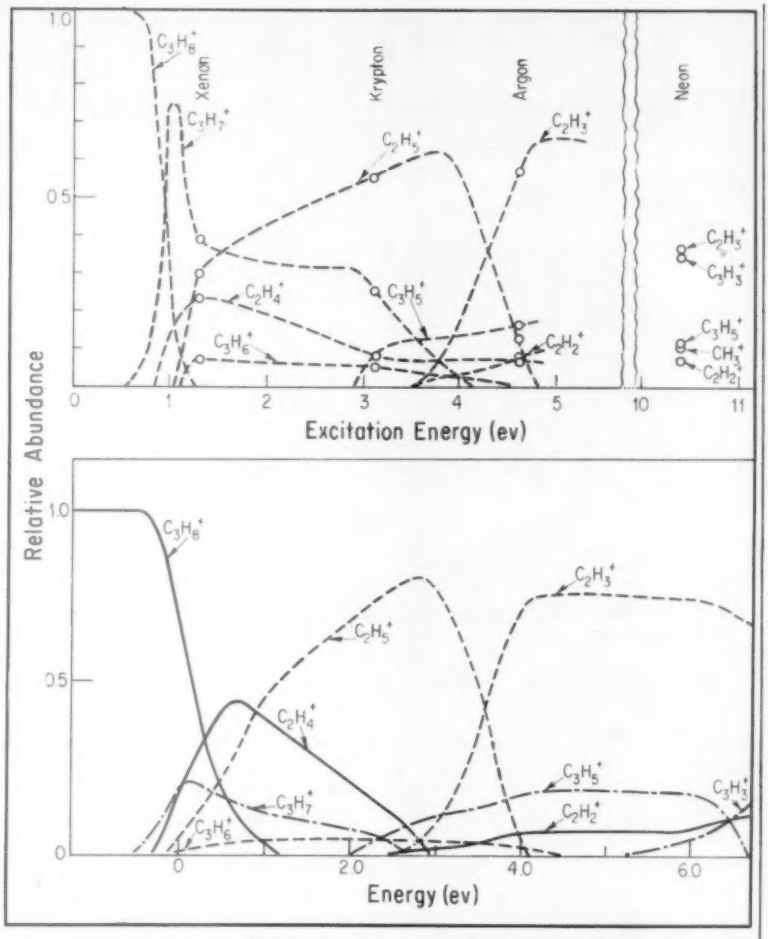


FIG. 3. RELATIVE ABUNDANCES (above) of ions resulting from decomposition of excited propane molecular ions ($C_3H_8^+$) as a function of excitation energy. Curves drawn between experimental points are hypothetical

FIG. 4. ELECTRON-IMPACT CURVES (below) of Chupka and Kaminski are remarkedly similar to charge-transfer curves if energy scale is shifted

the relative velocity of colliding particles cannot be determined. There is no possibility of measuring the current of primary ions and their energy is not homogeneous because they are formed in different places between the case and trap. Nevertheless, in a mixture of two gases the ratio of cross sections for different charge-transfer reactions can be approximately measured. If in a mixture of gases A and B charge transfer reactions

$$A^+ + A = A + A^+ \qquad (1)$$

$$A^+ + B = A + B^+ \qquad (2)$$

and

$$B^+ + B = B + B^+ \qquad (4)$$

take place and if the partial pressure of gas B is made sufficiently low, the measured current of B^+ ions is due only to reaction 2. The following equations therefore apply:

$$i_{s_A} = i_{p_A} n_A l Q_A$$

$$i_{s_B} = i_{p_A} n_B l Q_B$$

$$Q_A/Q_B = i_{s_A} n_B / i_{s_B} n_A$$

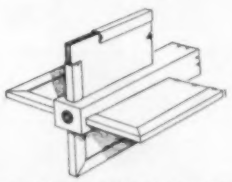
where i_s and i_p are the secondary- and primary-ion currents of gas, n is the number of molecules in 1 cm³ in the chamber region, l the length of the exit slit and Q the reaction cross section.

The ion source used in the work here was the same as that described by Nier (*15*). The electron current to the trap was stabilized at a value of about 30 μa; the voltage difference between filament and chamber (V_{FC}) was usually 5 v. The total gas pressure in the region of the chamber was necessarily higher than in Nier's source, usually about 5×10^{-5}–5×10^{-4} mmHg. The partial pressure of inert gases in the mixture introduced in the source was 5–10

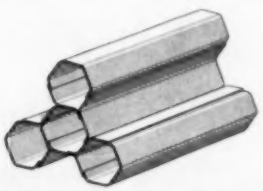
an effective material for neutron shielding

Boral is a uniform dispersion of boron carbide crystals in aluminum. Its high boron carbide content (up to 50%) enables it to absorb thermal neutrons without the production of hard gamma rays.

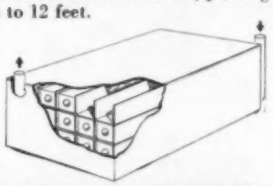
Boral Plate can be worked to meet the requirements of a wide range of shielding applications. It can be drilled, tapped, punched, sawed, sheared, formed, and welded. The accompanying sketches show typical designs and assembly methods.



Shut-down Control Rod for Reactors
Assembly of this unit is made by arc welding. All edges of Boral Plate are clad. The center bar is tapped to receive the threaded rod.



Storage Cells for Fresh Fuel
Cells are usually used in assemblies of several fuel units, encased in aluminum or stainless steel cylinders. The Boral shapes should have corner radii of 3/4"; length can be up to 12 feet.



Water-cooled Boral-lined Case for Spent Fuel Elements
This Boral-lined aluminum case with egg-crate type separators for the transportation and storage of spent fuel units, is assembled from Boral Plate by arc welding.

Typical and Potential Applications
Reactor shields, neutron curtains, shutters for thermal curtains, safety rods, storage and shipping containers for fissionable material, fabricated boxes for radiation-sensitive devices, protective shields for easily activated components.

Brooks & Perkins, the first commercial producer of Boral, invites you to send for technical data and literature. 60-T-11

BROOKS & PERKINS, INC.
1926 W. PORT STREET • DETROIT 16, MICHIGAN
Offices in Washington and New York

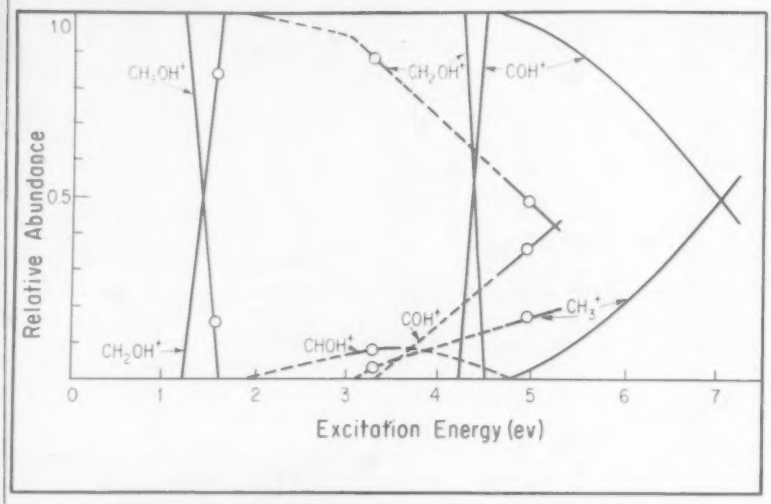


FIG. 5. EXPERIMENTAL ABUNDANCES for methyl alcohol (CH_3OH) show poor agreement with theoretical curves (solid lines) of Ref. 19

times higher than the partial pressure of the gas studied. The current of secondary ions depends among other things on the current of primary ions and, hence, also on the voltage difference between chamber and trap (V_{CT}). Depending on the value of V_{CT} the secondary current was between about 10^{-13}a and the lowest detectable limit 5×10^{-16}a. To estimate the inhomogeneity in primary-ion energy we traced the equipotential lines in the region of the trap. We concluded that about 75% of the primary ions had kinetic energy in the limits 0.9–1.0 eV_{CT}. The lowest energy was E_k = I.P. − V_{TC} (I.P. is the ionization potential of the inert gas used.)

Experimental Results

We obtained secondary mass spectra by the method described for mixtures of inert gases with a number of hydrocarbons. In argon-methane mixtures, except for a small quantity of secondary CH^+_4 ions, mostly CH^+_3 ions are formed following the reaction

$$A^+ + CH_4 = A + CH^+_3 + H \qquad \Delta H = -1.36 \text{ ev}$$

This reaction was reported by Lindholm (*7*) and used by Meisels, Hamill and Williams (*15*) to explain the radiolysis of methane in presence of argon. Moreover charge-transfer leads evidently to the formation of CH^+_2 ions by a reaction

$$A^+ + CH_4 = A + CH^+_2 + H_2 \qquad \Delta H = -0.16 \text{ ev}$$

From the table we can see that the ions CH^+_3 and CH^+_2 in the Xe-CH_4 mixture or ions $C_2H^+_3$ and $C_2H^+_2$ in the Xe-C_2H_4 mixture are formed by endothermic reactions. These reactions bear evidence that in collisions of polyatomic molecules with ions that have translational energies of the order 10–100 ev or more the kinetic energy of relative motion can be converted to internal molecular energy. This fact was clearly shown by Talroze (*17*).

The participation of kinetic energy in the energy balance means that the excitation energy is no longer simply equal to R. E. − I. E. but can be greater by an amount that varies between zero and a maximum value determined by the momentum and energy conservation laws. However in collisions energetic enough to allow conversion of kinetic energy into excitation energy, the conservation laws will require that the secondary ion emerge with a relatively high velocity in the direction parallel to the long axis of the slits. We were able to discriminate against these ions by reducing the length of the exit and collector slits from 10 mm to 4 mm and in some cases even to 1 mm. These changes sufficed, in theory, to prevent secondary ions from reaching the collector, with velocities in the perpendicular direction of 0.004–0.04 ev.

TOP NUCLEAR MATERIALS

EUROPIUM OXIDE
SAMARIUM OXIDE

Available from
Vitro
right now!

HIGH BURNUP
MINIMUM DAMAGE
EFFECTIVE NEUTRON ABSORBER
STABILITY UNDER RADIATION

By tailoring to your individual requirements, substantial cost savings are possible.

Clip this ad and mail to Vitro today for:
☐ Technical data
☐ Further information on any aspect of rare earth technology

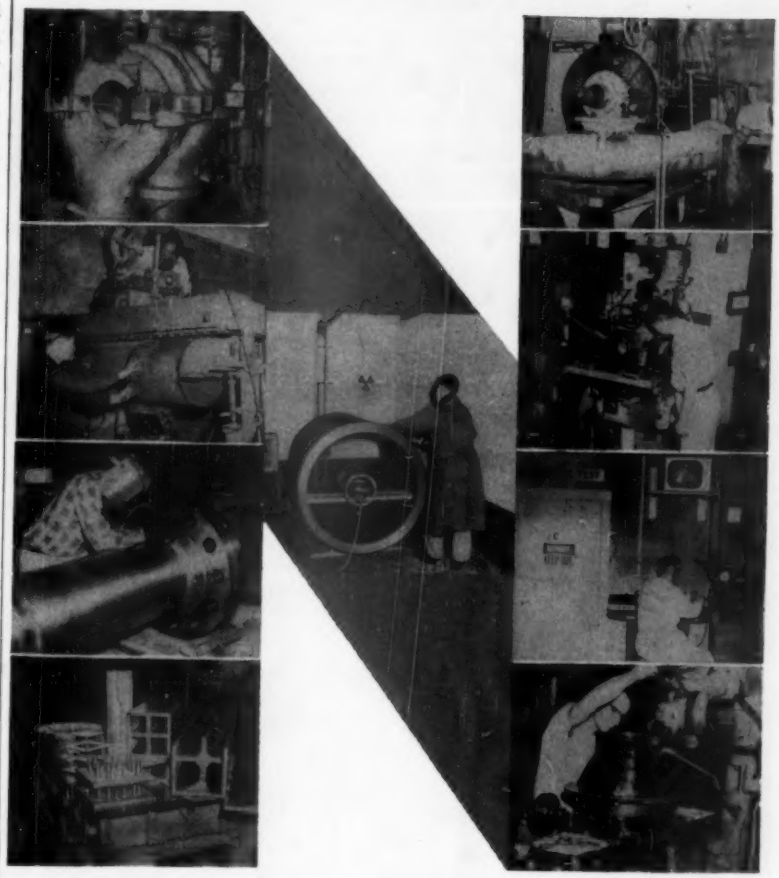
VITRO CHEMICAL COMPANY
A SUBSIDIARY OF VITRO CORPORATION OF AMERICA
342 MADISON AVENUE
NEW YORK 17, NEW YORK

The only remaining difficulty in defining the excitation energy of the molecular ions consisted in the facts that the ground states of inert-gas ions are doublets ($^2P_{3/2}$ and $^2P_{1/2}$) and that the abundance of the ions in the two states changes with the electron energy. For Xe^+ ions these states are separated by an energy 13.44–12.16 = 1.3 ev, for Kr^+ ions by 14.67–14.00 = 0.67 ev and for A^+ ions by 15.97–15.76 = 0.18 ev. We tried to overcome this inconvenience by measuring the relative abundances of secondary ions at low ionizing-electron energies—near or below the ionization potential of the higher lying state. A sharp cut-off of the ions with higher recombination energy could not be attained because of the spread in electron energy. As a practical solution we measured the relative abundances of secondary ions as a function of voltage difference between chamber and trap (which determines the energy of electrons in the region of the trap) and extrapolated the curves to those values of V_{CT} at which the nominal energy of electrons ($eV_{FC} + eV_{CT}$) was equal or about 0.5 ev below the threshold energy of the lower ground state (Fig. 2). This procedure minimized at the same time the kinetic energy of the primary ions, although the influence of kinetic energy on the results seems to be already insignificant at these energies.

Using this extrapolation procedure we observed the charge-transfer reactions in mixtures of inert gases with methane, ethylene, propane and methyl-alcohol and constructed the corresponding breakdown curves (Figs. 3–5). It has been suggested that the abundances of secondary ions might be explained applying the resonance rule (*7, 11*). Our results indicate that this is not the case. The similarity of our breakdown curves to those determined both experimentally or theoretically by other workers prove that the fragmentation mechanism of excited polyatomic ions is presumably independent of how the excitation energy is supplied. The results appear to be the same for excitation by electron impact or by charge transfer. The relative abundances of the secondary ions must therefore be determined by the fragmentation mechanism of the excited ions.

We can compare the breakdown curves determined for propane by the charge-transfer method with the normalized second-differential-ionization-efficiency curves derived by Chupka

A COMPLETE *Start-to-Finish Service* by NEWBROOK



NEWBROOK is an experienced organization with research, development and production facilities and capabilities to render a Start-to-Finish service.

We have a small, efficient plant, completely integrated with machines, men and "know-how." Our engineering and technical specialists have an extensive background in mechanical, electrical and hydraulic design and production. Our welders are certified and skilled in the welding of all the special metals used in atomic and missile components.

Newbrook offers you quality, reliability and delivery "on time." Let us quote on your requirements.

NEWBROOK
MACHINE CORPORATION
SILVER CREEK • NEW YORK

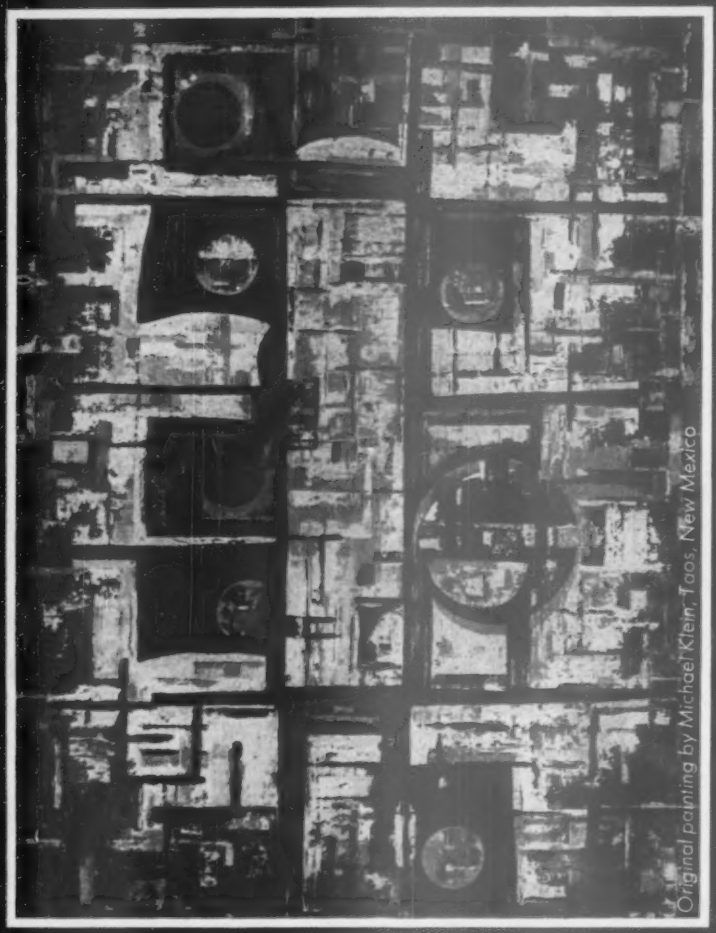
NEWBROOK is now producing nuclear hardware components, pressure vessels, vacuum equipment and other atomic products.

Our customers include nuclear and atomic contractors working on A.E.C. projects.

NEWBROOK is well known for its part in the production of Turbines, Launchers, Hydraulic Pumps, Shields, Starters, Detector Rod Mechanisms for Atomic Piles, Sub-Assemblies for Nuclear Reactors, Testing Devices, Vacuum and Pressure Furnaces . . . and many more.

Mathemagical Machines ?

Maybe they are not really magical, but modern computers are marvelous aids to solving the complex problems arising from research. With the addition of an IBM 7090 and the super-computer STRETCH, Los Alamos Scientific Laboratory has become one of the most advanced electronic computer centers in the world. Such machines are required to perform in a reasonable time the billions of computations involved, for example, in the design of nuclear weapons and nuclear reactors, and, in problems of molecular biology and magnetohydrodynamics.



Qualified applicants are invited to send resumes to: Director of Personnel, Division 61-77

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin. U.S. citizenship required.

and Kaminski from electron-impact studies (*17*, Fig. 4). The similarity of the two graphs is remarkable when the energy scale in Fig. 4 is shifted about 1.2 ev to the left. The only discrepancy is the relative heights of the curves for $C_2H^+_4$ and $C_3H^+_7$. For methanol the breakdown graph (Fig. 5) can be compared with theoretical curves only (*18*). There is considerable discrepancy between the two graphs at higher excitation energies, which suggests that the calculated rates vary too strongly with excitation energy.

The ease with which reliable data on breakdown curves in charge-transfer reactions of polyatomic molecules with inert gases ions can be obtained suggests some interesting applications for radiation chemistry. For instance in the radiolysis of a mixture of CH_4 or C_2H_4 with one of the inert gases in very great excess the energy would be transferred to hydrocarbon molecules mainly by charge transfer. With the primary reaction thus definitely known attempts to understand the over-all picture of radiolysis results would be substantially simplified.

* * *

Paper based partly on talk delivered before a Gordon Research Conference on Radiation Chemistry, New Hampton, N. H., 1960.

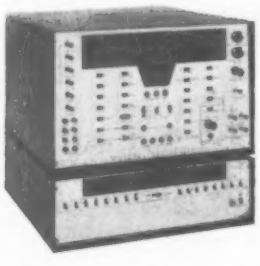
BIBLIOGRAPHY

1. S. C. Lind, D. C. Bardwell, *J. Am. Chem. Soc.* **48**, 1575 (1926)
2. R. C. Palmer, D. C. Bardwell, paper presented at the 134th National Meeting of the American Chemical Society (Chicago, Sept. 7–12, 1958)
3. F. W. Lampe, *Radiation Research* **10**, 691 (1959)
4. L. M. Dorfman, A. C. Wahl, *Radiation Research* **10**, 680 (1959)
5. P. S. Rudolph, S. C. Lind, *J. Chem. Phys.* **33**, 1572 (1960)
6. J. B. Hasted, in "Advances in Electronics and Electron Physics," vol. 13 (Academic Press Inc., New York, 1960)
7. E. Lindholm, *Proc. Roy. Soc. (London)* **66A**, 1068 (1953)
8. E. Lindholm, *Arkiv Fysik* **18**, 219 (1960)
9. H. von Koch, E. Lindholm, *Arkiv Fysik* **19**, 123 (1961)
10. V. L. Tal rose, et al, *Pribory i tecknika experimenta*, No. 7, 87 (1960)
11. G. K. Lavrovskaya, M. I. Markin, V. L. Tal rose, *Kinetika i kataliz* **2**, 21 (1961)
12. H. M. Rosenstock, et al, *Proc. Natl. Acad. Sci. U. S.* **38**, 667 (1952)
13. F. H. Field, J. L. Franklin, "Electron Impact Phenomena and Properties of Gaseous Ions" (Academic Press Inc., New York, 1957)
14. C. E. Melton, *J. Chem. Phys.* **33**, 647 (1960)
15. A. O. Nier, *Rev. Sci. Instr.* **18**, 398 (1947)
16. G. G. Meisels, W. H. Hamill, R. R. Williams Jr., *J. Phys. Chem.* **61**, 1456 (1957)
17. V. L. Tal rose, paper presented at the I. A. E. A. Symposium on Chemical Effects of Nuclear Transformations (Prague, Oct. 24–27, 1960)
18. W. A. Chupka, M. Kaminski, paper presented at the Washington Meeting of the American Physical Society (May 1, 1959)
19. L. Friedman, F. A. Long, M. Wolfsberg, *J. Chem. Phys.* **27**, 613 (1957)

THERE MUST BE AN EASIER WAY!

THERE IS: *FAST* *

* In radiation analysis, accumulation of the energy distribution curve is usually followed by quantitative interpretation of the results. The most frequent first step in the interpretation is the determination of the intensity of individual lines by integration of the areas involved. With *FAST*, the operator selects a region of interest, depresses a switch, and the area of the selected region is quickly indicated in memory channel number one. The answer is then typed out by means of the IBM computer readout typewriter. Other regions of interest may be quickly integrated in the same manner. Answers are exact, and operation is simple and dependable. This is *FAST*. (Fast Area Sub-Totalling.)

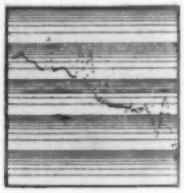


MODEL ND-130A ANALYZER-COMPUTER

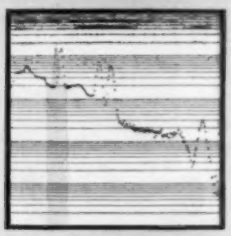
The Model ND-130A includes the analysis and summation circuitry (**FAST**) as well as spectrum stripping circuitry. It costs no more than the superb Model ND-130.

NUCLEAR DATA INC.

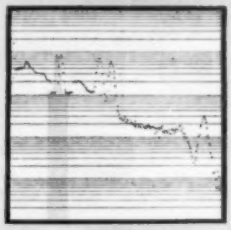
3833 WEST BELTLINE HY.
MADISON / WISCONSIN



HERE'S HOW IT WORKS:

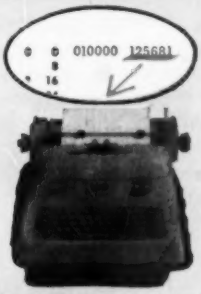


Step 1: Analyze the unknown radiation source. Correct for background counts, if desired, by utilizing the data reduction controls.



Step 2: Select any region of the spectrum by simple switch operations. The selected regions are displaced for instant visual examination. The channel numbers involved are indicated exactly by the switch settings.

Step 3: Depress the "initiate computer cycle" button. The sum of all data points in the selected region, only, is accumulated in a second or two. The sum, divided by ten if desired in order to avoid count overflow, is recorded into analyzer channel number one.



Step 4: Read out the answer in channel one by means of the IBM computer readout typewriter.
That's all. No more tedious adding machine operations. No more adding errors.

Precision of analysis and instrument dependability are nothing less than remarkable in the ND-130 series analyzers. For example, of sixty units delivered prior to July, all except one (probably damaged during installation) have operated without failure up to that date. No other analyzer model has ever approached this record. Almost flawless performance, combined with such features as punched tape read-in and read-out, internal data reduction, fast area sub-totalling, precision logarithmic curve display, and others, make this analyzer the best in the field.

THERMOCOUPLE COMPONENTS

Wires, insulators, protecting tubes, heads, blocks, connectors and miscellaneous components—supplied in countless combinations, for highest possible accuracy in any given application. Thermocouple components are among many thousands of accessories—all available from a single dependable source—that can help your instruments perform at their very best.

Get complete details from your nearby Honeywell field engineer, or write today for Catalog G100-3.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control SINCE 1885

NUCLEAR BOOKSHELF

"Nuclear revolution in the Navy . . ."

Polaris!

By JAMES BAAR and WILLIAM HOWARD (Harcourt Brace & Co., New York, 1960, $4.50, 245 pages)

The Seas and the Subs

By ED REES (Duell, Sloan and Pearce, New York, 1961, $4.50, xviii + 233 pages)

Reviewed by JOHN KENTON, NUCLEONICS.

A sure measure nowadays of the coming of age of any new institution or phenomenon, in almost any walk of life, is publication of a spate of "you are there" or "this is how it was" (interlaced with a good dose of "this is what it Really Means") books reporting on the new institution or phenomenon. The Polaris submarine program has now been accorded this accolade.

The Baar-Howard book, by the associate editor and managing editor, respectively, of *Missiles and Rockets* magazine, is devoted entirely to the story of how Polaris became an operational weapons system in the incredibly short span of 4½ years.

The Rees book, by a former military correspondent for *Time* magazine, paints on a broader canvas. About half the book is devoted to the history of the Polaris project. In addition, it also gives brief accounts of *Nautilus* and the whole nuclear revolution in the Navy, of our antisubmarine forces, and of the still-little-known Operation Rainbarrel, the Naval Research Laboratory program for checking whether or not Russia has detonated any atomic bombs by analyzing Aleutian rainwater for cesium traces.

"Polaris!" begins at Peenemünde in World War II with the idea of a German rocket engineer whose brother was skipper of a U-boat. The engineer sold the Peenemünde command on an experiment: he bolted some 4½-ft long mortar tubes to the foredeck of his brother's submarine, ran waterproof cable to a firing switch inside the sub, went out 74 ft below the surface of the Baltic, and achieved the first successful rocket launchings from a submerged submarine. This was in 1942. One shudders to speculate what turns World War II might have taken had the German Navy understood the potential of the new weapon. But the Navy, offered the idea by Peenemünde's commander, Army General Dornberger, replied that if there were to be submarine rockets the Navy would design them. The reports on the experiment were filed and forgotten; the Allies were taken off the hook by interservice rivalry—the same interservice rivalry that was to become one of Admiral Raborn's most troublesome obstacles 16 years later.

The book captures well the spirit of the breakneck schedules and deadlines under which and against which all Polaris project workers labored day and night, seven days a week, "thirteen months a year." Navy men spoke almost casually about wives "quitting" when they couldn't stand their husbands' pace.

Baar and Howard are sharply critical of the Eisenhower Administration's failure to support the Polaris program adequately because of its budget-as-usual attitude, and contends that a larger fleet of Polaris submarines could have been built even faster had Eisenhower not enforced a "shortsighted" ceiling on the defense budget.

Both books are written in snappy journalistic style for fast reading, and are packed with accurate information about a vital development.

Resonance Absorption in Nuclear Reactors

By LAWRENCE DRESNER, International Series of Monographs on Nuclear Energy, div. X, vol 4 (Pergamon Press, New York, 1960, $6, x + 131 pages)

Reviewed by BERTRAM WOLFE, Atomic Power Equipment Department, General Electric Co., San Jose, Calif.

The theory of resonance absorption in nuclear reactors has reached the

stage when it can provide relatively accurate information from basic cross-section data. Indeed it sometimes appears that theoretical results are more to be trusted than experimental; in the case of nonthermal reactors, experimental results are lacking. Thus for practical reasons, as well as for the general understanding of a process important in a nuclear reactor, reactor physicists will welcome a book that summarizes in detail and with perspective the important work in the field of resonance absorption.

Although Dresner's monograph is a self-contained treatise, it requires a background in reactor theory for full understanding. The first six chapters give the basic theory of resonance absorption in both homogeneous and isolated-lump systems including the effect of Doppler broadening. The discussion of a slowly-varying absorption cross section in a homogeneous system is an illuminating and original analysis that starts from the Hurwitz WKB approach, introduces the Goertzel-Grueling and Wigner kernels as approximations in the Hurwitz analysis, and then gives physical meaning to the approximations by using the Weinberg and Wigner Placzek-function method. For full appreciation of the work, one must presuppose a knowledge of the original synthetic kernel approach.

Since the isolated-lump treatment relies heavily on the concept of escape probability, there is a short chapter on transport-theory fundamentals that gives the required background. By means of the Wigner approximation for the escape probability and the assumption of flat flux, the lumped system is related to the homogeneous system that is treated earlier. The author investigates the adequacy of these approximations in some detail.

The seventh chapter contains a discussion of special topics. Included is a particularly clear description of the original Dancoff-Ginsburg work, and its generalization by Nordheim. A new alternate formulation of the lump-interactions effect is discussed that, in essence, involves a first-order correction to the resonance flux due to neutron depletion by the lattice of resonance absorbers. The results are very similar to Bell's, but unfortunately the author makes no serious comparison

High Pressure-
High Temperature
Equipment*

AUTOCLAVE ENGINEERS
ERIE, PA.

SPACESAVER
Stainless Steel Valves

Here is a stainless steel tubing valve—precision made yet rugged—which gives you improved performance *plus* savings in space, time and money. The SpaceSaver is more compact and lighter in weight than any other valve of comparable tubing size and pressure rating. Although capable of handling gases and liquids at 12,000 p.s.i., these valves are priced for practical use at all lower pressures. Full port openings—with minimum pressure drop through the valve—are a major advantage. And installation is quick and easy—no threading, swaging, flaring, welding or special tools are required.

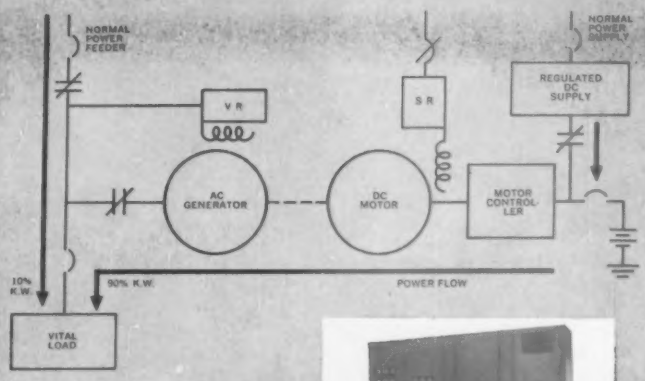
AE SpaceSaver Valves are of 316 s.s. construction and are available for ⅛" O.D., ¼" O.D., ⅜" O.D. or ½" O.D. tubing.

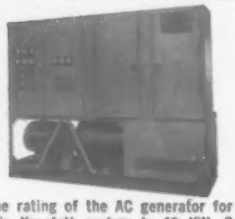
Bulletin 257 gives complete information—yours for the asking.

AUTOCLAVE ENGINEERS, INC.

2934 West 22nd Street • Erie, Pa.

* Designers and Builders of High Pressure-High Temperature Equipment including: Valves • Fittings • Stirred Autoclaves • Reactors • Pumps • Compressors • Complete High Pressure Package Systems including Instrumentation and Controls.





The rating of the AC generator for this Kearfott system is 40 KW, 3 phase, 60 cycle, 460 volts.

CONTINUOUS UNVARYING POWER FOR VITAL INSTRUMENTATION IN CHECHEMICAL PROCESSING

A TYPICAL APPLICATION OF KEARFOTT UNINTERRUPTED POWER SYSTEMS

In chemical processes where even a split-second interruption of computers and related instruments can cause heavy losses, protection against power failure pays high dividends on a relatively modest investment. Take, for example, the Kearfott system pictured here, which assures surge-free entrance of emergency power in zero time in case the normal input varies or fails.

In normal operation, the DC motor runs continuously on power from the static supply, which also keeps the batteries fully charged at all times. The AC generator operates in parallel with the main power and furnishes about 90% of the vital load requirement.

If the main power fails, the DC motor continues to run, drawing its current from the batteries. Simultaneously, the AC generator assumes 100% of the vital load. When main power is restored, the system automatically reverts to normal operation.

Kearfott systems are available with generator ratings to 150 KVA 60 and 400 cycles, single and polyphase, and provide frequency, voltage and transfer regulation as required by the application.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Nuclear Bookshelf

Department starts on page 116

to his work. Also, the relationship between the Dancoff-Ginsburg type of treatment and the new approach in the book is not clear; the reader may wonder about the area of application of each. Other topics touched upon are: the clumped-rod problem to which the author's new method is applicable, flux perturbation of one resonance due to absorption in another resonance, absorption in the unresolved resonance and the spatial distribution of the resonance flux. The book closes with a chapter comparing experiment and theory, and the author's conclusion that the theory is adequate to within ~10% for calculating resonance integrals in thermal reactors.

I find that when the theory in the book is well developed, (i.e., material covered in first six chapters), Dresner's treatment is clear and satisfying. However, an expanded seventh chapter with a fuller discussion and a more explicit identification of basic uncertainties would be valuable. The book might also have benefited from a discussion of application of the work to nonthermal reactors and the use of multigroup techniques and computers in resonance absorption calculations.

Since Dresner's book is the only up-to-date work that covers the entire theory of resonance absorption in detail, it will be valuable to workers in the reactor field both as a source of basic theory and as a reference and guide to the original literature.

Scientific Russian

By JAMES W. PERRY (2nd ed., Interscience Publishers, New York, 1961, $9.50, xxvi + 565 pages)

Scientific Russian Guide

By MARY A. EMERY and SERGE A. EMERY (McGraw-Hill Book Co., New York, 1961, $4.50, vii + 189 pages)

Although these can not really be called nuclear books, the growing awareness among workers in the nuclear field that a knowledge of Russian is important to their work is making many learn the language. These two books will help those people who want to learn Russian from a scientific angle so that they can read Russian scientific journals and papers. "Scientific Russian" contains a thorough background in grammar and vocabulary—emphasizing in the vocabulary and reading

exercises scientific words and discussions (on such subjects as nuclear energy) rather than the usual "pen-of-my-aunt" sentences. Not only is the book useful for classroom scientific Russian courses, but also, because of its clarity, it can be used for self-study. The other book, "Scientific Russian Guide," designed principally as a reader, contains no grammar. The graded-reading exercises cover about twenty areas of science including nuclear energy, physics and mathematics as well as biographies of famous Russian scientists. At the end of each reading section are questions to test the reader's comprehension as well as a complete vocabulary of the new words in the section. The book is an excellent supplement to a scientific Russian course—especially for people at the early stages of learning Russian who need practice reading scientific Russian, but may find the articles in *Atomnaya Energiya* and other Russian journals too advanced.

—MBG

The Physical Principles of Astronautics

By ARTHUR I. BERMAN (John Wiley & Sons, Inc., New York, 1961, $9.25, xv + 350 pages)

This well-written exposition of the mechanics of astronomy and space flight is written on a level useful to the technical man involved in the nuclear-space field who needs more than an elementary understanding, but does not count himself a specialist in space matters. In the first four chapters the author reviews basic information about the solar system and principles of classical mechanics; the next three chapters deal with the intricacies of orbit calculations and the final chapter treats propulsion dynamics. Ten appendices add a variety of reference material including a glossary and bibliography.

—HLD

BOOKS RECEIVED

Codes for Reactor Computations, Proceedings of the Seminar on Codes for Reactor Computations Sponsored by the IAEA (International Atomic Energy Agency, Vienna, Austria, 1961,

GLC
GRAPHITE
Serves NUCLEAR REQUIREMENTS throughout the world

The uniformly high quality of GLC graphite for nuclear applications has been proved in thermal columns and reflectors in operation throughout the world, as well as in sub-critical assemblies operated by leading American Universities.

We are equipped and staffed to supply a superior graphite promptly and economically for nuclear applications of all kinds. Our facilities for expediting both domestic and overseas shipments are excellent.

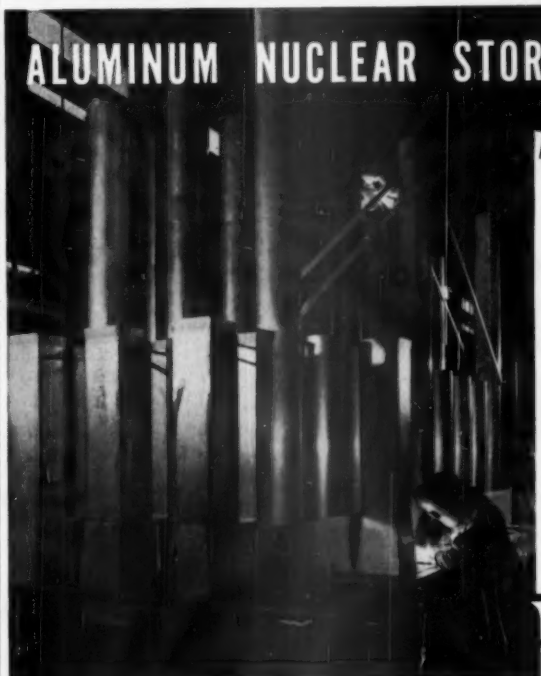
For an introduction to GLC graphite—and to one of the world's outstanding graphite producers—write for a free copy of our illustrated brochure, "Graphite For Diversified Industrial Applications".

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST

GREAT LAKES CARBON CORPORATION

18 EAST 48TH STREET, NEW YORK 17, N.Y. OFFICES IN PRINCIPAL CITIES

ALUMINUM NUCLEAR STORAGE RACK



by CPC

Engineered, machined and fabricated all aluminum nuclear spent fuel element storage rack designed by Stone and Webster, Boston, Mass. for Yankee Atomic Plant, Rowe, Mass.

QUALIFIED WELDERS

A.S.M.E. - National Boards
Aircraft - MIL-T-5021A
Navy - STD-248A
Code Inspection by Mutual Boiler and Machinery Insurance Company

WRITE FOR ALUMINUM BROADSIDE

CPC engineering

STURBRIDGE, MASS.

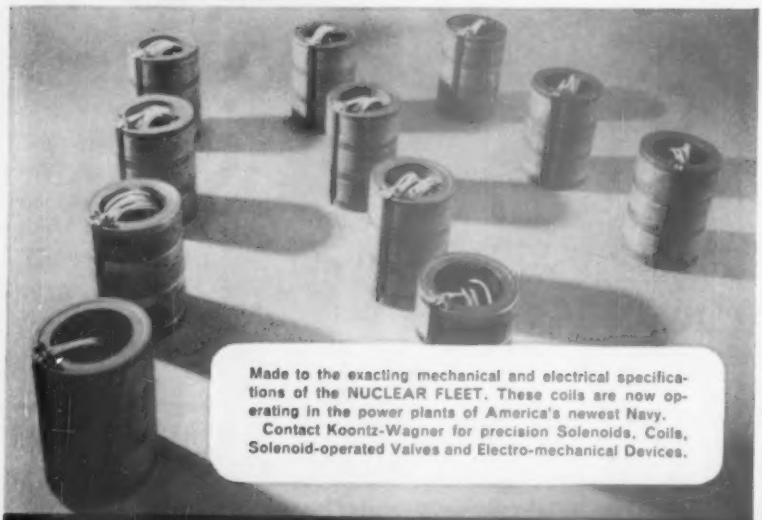
On guard just in case! When trouble strikes, emergency action must be *immediate*. Contamination from acids, chemicals and other industrial caustics requires first aid *now*... HAWS Decontamination Booths are your best stand-by protection against serious injury. MODEL 8600: Fiberglass decontamination booth; spray nozzles and eye/face wash activated by weight on treadle base.

Since 1909 HAWS **DECONTAMINATION BOOTH**

for complete catalog write

HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, California

MAGNETIC COILS by KOONTZ-WAGNER



Made to the exacting mechanical and electrical specifications of the NUCLEAR FLEET. These coils are now operating in the power plants of America's newest Navy.
Contact Koontz-Wagner for precision Solenoids, Coils, Solenoid-operated Valves and Electro-mechanical Devices.

MANUFACTURING DIVISION OF

KOONTZ WAGNER ELECTRIC COMPANY INCORPORATED

516 N. MICHIGAN ST. SOUTH BEND, INDIANA

Nuclear Bookshelf

Department starts on page 116

$8, 538 pages). A report on the worldwide state of reactor design using computing machines as presented by 20 different countries at an IAEA seminar in April 1960. The 42 contributions are listed under five major subject headings: Facilities for Reactor Computations; Utilization of Computers for Reactor Problems: Code Libraries, Existing and Planned; Universal Languages; and Numerical and Statistical Methods.

Control of Nuclear Reactors and Power Plants, 2nd ed., by M. A. Schultz (McGraw-Hill Book Co., New York, 1961, $12.50, ix + 462 pages). Revised and updated to fill the reader in on the new developments in the reactor-control field since 1955 when the first edition was published, this new edition discusses basic control problems of all types of reactors—from homogeneous to boiling water. Thus the new edition overcomes the fault of the old one which, because it was based on technology developed in the early naval reactor program, dealt only with highly enriched U^{235} water-cooled and water-moderated reactors. Other additions include a chapter on elementary servomechanisms that will aid the teacher and student without an electrical-engineering background, a new chapter on boiling-water reactors and additional sections on homogeneous reactors. Because the growth of the reactor-control field continues to be great, the author could not cover all new material; he has thus added over 400 new references that will help the reader learn about developments not covered in detail in the book.

Introduction to Nuclear Engineering, 2nd ed., by Raymond L. Murray (Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961, $12, ix + 462 pages). This second edition adds to Murray's popular nuclear-engineering textbook much of the material that has been developed since 1954 when the first edition came out. Updatings and additions cover the following fields: particle accelerators, fuel production and consumption, fuel costs, properties of new materials, shielding analysis, reactor experiments, isotope uses, direct conversion, ion propulsion of space vehicles and thermonuclear devices.

At sea with the fleet, on patrol or a cruise, there's no time or place for major repairs or replacements. That's why ships of the U.S. Navy as well as 95% of America's merchant fleet are Leslie-equipped. Almost all shipowners, operators and builders have learned to depend on Leslie controls to keep ships moving from port to port on schedule—without costly, time-consuming mishaps.

With its 60 years' experience in producing and designing valve equipment for the marine industry, Leslie has developed fully dependable controls and regulators that insure trouble-free service, maximum resistance to corrosion and hard ship-board use.

Leslie products include *reducing valves* for steam, air and water; *temperature regulators* for steam and water systems; *pump pressure regulators* for steam driven pumps and turbines; *pilot mechanisms* and *diaphragm control valves* for liquid level and pressure and temperature control; and Leslie-Tyfon steam and *air whistles*. Write for complete information and application data.

TRADE LESLIE MARK

REGULATORS and CONTROLLERS

Leslie Co., 241 Grant Ave., Lyndhurst, New Jersey

ENGINEERED FOR MARINE SERVICE

Diaphragm control valves

Control pilots for pressure, temperature and level

Pressure reducing valves

Temperature regulators

Pump pressure regulators, Differential pressure regulators

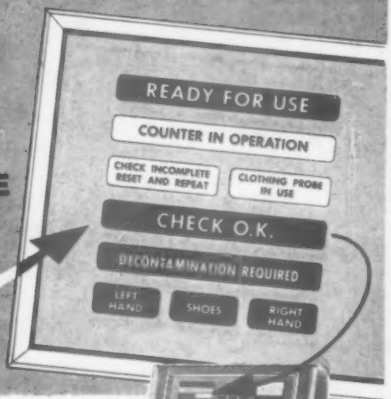
Strainers

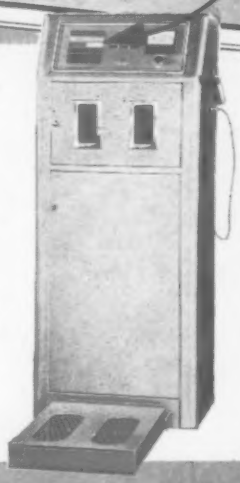
Steam and air whistles, automatic whistle controls

NO INTERPRETATION NEEDED!

ONE LOOK

SHOWS YOU WHETHER YOU ARE CONTAMINATED ...and WHERE!





ONLY T/A HAND & SHOE MONITORS offer this outstanding feature!

MODEL HSM-10A provides completely automatic detection and measurement of beta-gamma contamination on the back and palm of each hand and the bottom surfaces of both shoes. No skill is required in its operation.

GREATER ALARM SENSITIVITY. The Model HSM-10A employs the decade scaling principle and offers new lower warning levels adjustable from 10 to 190 counts with variable time settings from 1 to 120 seconds. An external clothing probe with rate meter read-out and speaker is included.

WRITE FOR BULLETIN NO. 167

Another T/A exclusive...

Warning Lights on T/A PORTAL MONITOR locate contamination QUICKLY!

MODEL PPM-8 provides a quick efficient method of "head to toe" monitoring of personnel entering or leaving a controlled area. It features red warning lights, one at each of the 8 detectors, which enable the user to localize quickly the area of beta/gamma contamination.

WRITE FOR BULLETIN NO. 168

180° lead shielding around each detector minimizes the background count.

LIM-18 LAUNDRY INSPECTION MONITOR

A specially designed instrument for monitoring clothing and equipment worn in beta/gamma contaminated areas. 180° lead shielding around each detector increases the sensitivity of the instrument.

WRITE FOR BULLETIN NO. 168

TA

TECHNICAL ASSOCIATES

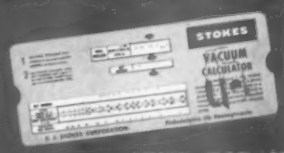
140 WEST PROVIDENCIA AVENUE • BURBANK, CALIFORNIA

a vacuum pump as dynamically balanced as...

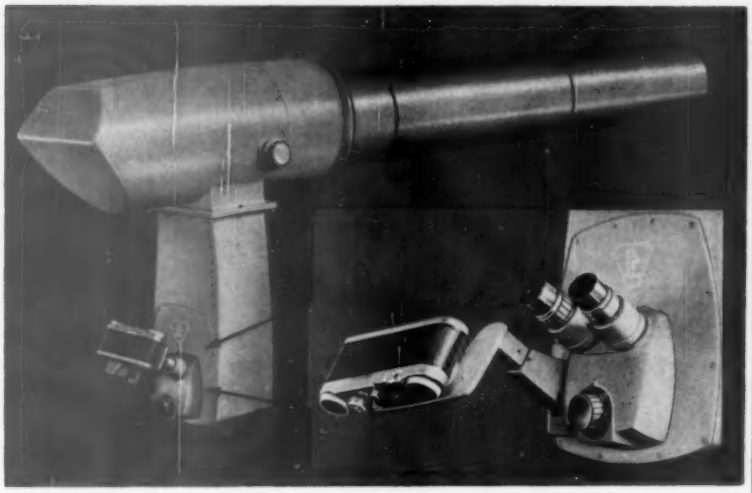
Engineered to give you years of vibration-free, superior operation, Stokes Series H Microvac pumps are the most advanced in their class. Exceptionally compact, Stokes pumps take up 50% less floor space than conventional vacuum pumps.

Learn all the reasons why Stokes offers you more pumping performance per dollar. Simply write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR ROAD, PHILA. 20, PA.

STOKES



SEND TODAY for your free Vacuum Slide Calculator!



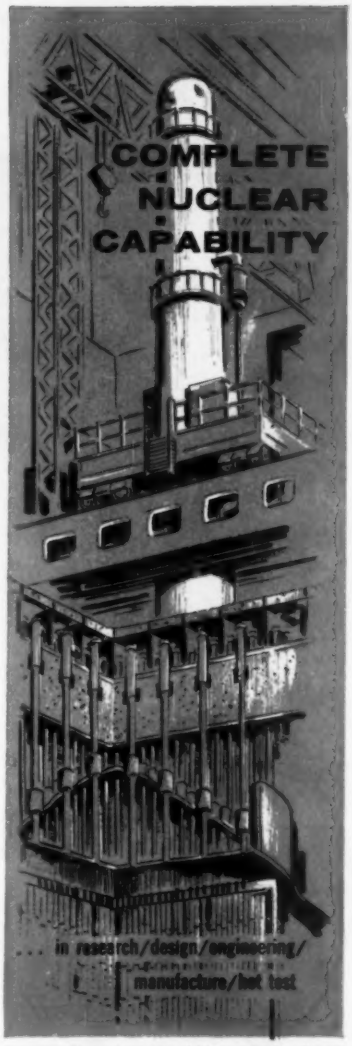
Remote-Control Stereomicroscope for Hot Cells

With this L-shaped instrument an operator can view radioactive materials in a hot cell through a microscope that has a range of magnification from 1 to 60×. The instrument has two main components: (a) the stereomicroscope with its zoom optical system and stereo camera and (b) a sealing tube that allows the instrument to be repositioned at different points in the hot cell without danger of contamination to the operator. Self-contained, built-in shielding, equivalent to 12 in. of lead, also protects the operator from radiation from the cell access port when the instrument is in position. The stereomicroscope with its 1 to 4× zoom system has three sets of wide-field eyepieces—10, 20 and 5.5×. In addition, a 35-mm camera that fits light-tight over the eyepieces will take stereo photographs of the materials in the hot cell. Since microscope components are all located on the outside of the hot-cell wall, there is no need for the mechanical linkages previously required to change objectives remotely. In addition, since the unit is mounted in the hermetically sealed tube, all instrument components can be removed without problems of decontamination.—Bausch & Lomb, Inc., Rochester 2, N. Y.

Neutron monitor. New neutron ionization chamber measures reactor neutron flux in the range 250–25 × 10^9 n/cm^2/sec in a gamma field of 15,000 r/hr maximum. The boron-lined ionization chamber, 2 ft long × 3⅛ in. in diameter, operates at temperatures up to 550°F.—Lionel Electronic Laboratories, 1226–38 Flushing Ave., Brooklyn 37, N. Y.

Diffusion cloud chamber for classroom demonstrations needs only a strong light, alcohol and dry ice to be ready for action; shipped completely assembled, chamber contains 165-mm-diameter glass cylinder, cover glass, aluminum bottom tray, aluminum top retaining ring, molded rubber gasket, absorbent vapor source, black dye, illustrated operation manual and alpha and beta sources.—Atomic Laboratories Inc., 3086 Claremont Ave., Berkeley 5, Calif.

Solid-state temperature-monitor and alarm system. Designed for reactor control to temperatures up to 1,500°F, unit has remotely adjustable, sensitive over- and under-temperature alarm with manual or automatic reset. Characteristics for 1,000°F temperature span are 0.2% temperature-to-output linearity with 2½-volt output; overall system accuracy is to 0.5%.—Astra Technical Instrument Corp., 12930 Panama St., Los Angeles 66, Calif. *(Continued)*



A comprehensive capability in all phases of nucleonics is offered by Royal Industries, Incorporated, through . . .

VARD Division — one of the world's major suppliers of nuclear components with experience in

- CONTROL ROD DRIVES
- ELECTRO-MECHANICAL ACTUATION
- REACTOR SERVICING EQUIPMENT
- POSITION INDICATING SYSTEMS
- FUEL HANDLING EQUIPMENT

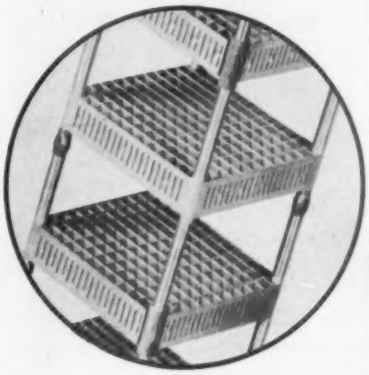
ROYAL RESEARCH Corporation — a subsidiary, with experience in isotope research, radio-chemistry, radiation investigation.

VARD

a division of Royal Industries, Inc.
2981 E. Colorado Blvd. • Pasadena, Calif.

STALKER PRODUCED

HONEYCOMB GRID ASSEMBLY for ENRICO FERMI FAST NEUTRON BREEDER REACTOR*



Stalker's skilled personnel plus Stalker's exclusive PROVEN ORTHOBRAZE METHODS of stress-free forming and high temperature brazing of intricate sheet metal assemblies assure a high quality assembly which will meet strictest requirements.

Highly adaptable to many precision stainless steel or super alloy fabrications — Stalker techniques are ideally suited for the production of honeycomb grids for reactor application.

Stalker engineering, prototype development and production facilities are available for customer use.

*(Lagoona Beach, Michigan)

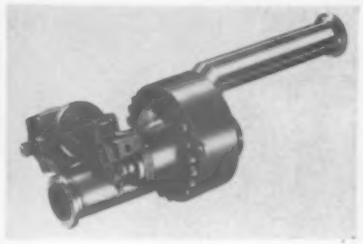
THE STALKER CORPORATION
905 Woodside Ave.
Essexville, Michigan

Phone: Bay City — Twinbrook 3-7562

Products and Materials

Department starts on page 123

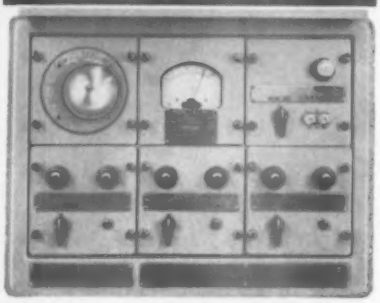
Isotope kit. No AEC license is needed for this kit that contains five long-lived isotopes: Pb^{210}-Bi^{210}, Co^{60}, Ce^{144}-Pr^{144}, Zn^{65} and C^{14}, as well as a tube of 100 aluminum sample pans, two micropipettes, a Clay Adams syringe and instruction manual.—Nuclear-Chicago Corp., 359 E. Howard Ave., Des Plaines, Ill.



For Hanford—1,050 valves control water flow for cooling. Valve provides flow of demineralized water up to 400 gal/min at temperatures to 600°F and pressures to 2,000 psi. Delivery of the process-tube outlet-diversion valves, an air-supply system and a remote control panel will be completed by April, 1962.—Chandler Evans Corp., W. Hartford 1, Conn.

Tiny radiation monitors (above), each based on ORNL design, are being distributed by five companies: Victoreen, REAC, NUMEC, Atomic Accessories (AA) and Landsverk. Each monitor is fountain-pen size, clips on clothes and emits warnings by chirping. In addition, Victoreen, NUMEC, AA and Landsverk monitors have neon lights that flash simultaneously with chirps; REAC monitor (SCRAM-1), which now has no light, will in a future model, SCRAM-2, contain a light that flashes only when monitor is exposed to

NEW MODULAR DESIGN SALINITY INDICATOR



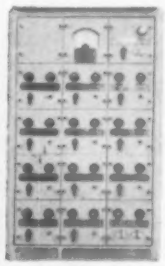
for marine and land based applications

Designed to indicate the amount of dissolved salts in boiler feed water, fresh water distillate, steam condensate, nuclear reactor cooling water, and similar applications.

Equipment provides for visual and audible alarm when contamination occurs as well as direct meter indication. Equipment will also actuate solenoid valves for automatic dumping or shut off of water having excessive salt content. Instruments can be calibrated in PPM Chloride, EPM Chloride, or micromhos/cm. Ranges as low as 0-1 PPM Chloride available.

Rugged valve type conductivity cells provided with constants as low as 1/100. Cells available with wide range of automatic temperature compensators.

COMPLETELY SYSTEMIZED TO YOUR REQUIREMENTS

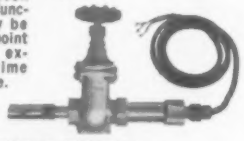


SYSTEM-SIZED

System is made up to your requirements from off-the-shelf, proven modules of specific functions. System may be sized from a single point to hundreds, and expanded at any time without obsolescence.

MODULAR DESIGN

Standard modules permit easy, in-the-field maintenance by non-technical personnel. Modules are mechanically keyed according to function eliminating possibilities of error.



SENSING ELEMENTS

As a leading supplier of conductivity cells, Industrial Instruments offers a wide choice of sensing elements meeting all functional and mechanical requirements.

WRITE for complete details. Specific systems problems welcomed.

Industrial Instruments Inc.
89 Commerce Road, Cedar Grove, Essex County, N. J.

ALITE® Helps New Princeton-Pennsylvania Accelerator Unlock the Atom's Secrets

By accelerating protons around a ring 80-feet in diameter to velocities approaching the speed of light, smashing them into a platinum target to disintegrate some of its atomic nuclei and studying the particles that shower out, scientists at the Princeton-Pennsylvania Accelerator will be gaining new knowledge about nature's basic building blocks.

Because extreme tolerances must be met in order to maintain the necessary control of the protons, only components of the finest materials and most careful workmanship were acceptable for use in the new machine.

We're proud that we at Alite were selected to produce the high alumina ceramic spacers which support, position and insulate the magnet pole pieces in the Princeton-Pennsylvania Accelerator.

The Alite formulation used in fabricating the thousands of magnet spacers required is 98% pure aluminum oxide. Alite was selected because of its high dimensional stability—dimensional tolerances on these parts were specified to ±.0002 inches, or about the diameter of a human hair.

In supporting the pole pieces, which generate huge magnetic forces, the Alite spacers are expected to be subjected to unit loads as high as 40,000 psi.

If you need a material that is rugged . . . will withstand elevated temperatures . . . has superior resistance to corrosion, abrasion, thermal shock and nuclear radiation . . . that has exceptional dielectric properties . . . that can be metallized and brazed to metal parts to form a vacuum-tight seal—then perhaps Alite is your answer.

Tell us your specific requirements. Our ceramic specialists will provide all possible assistance.

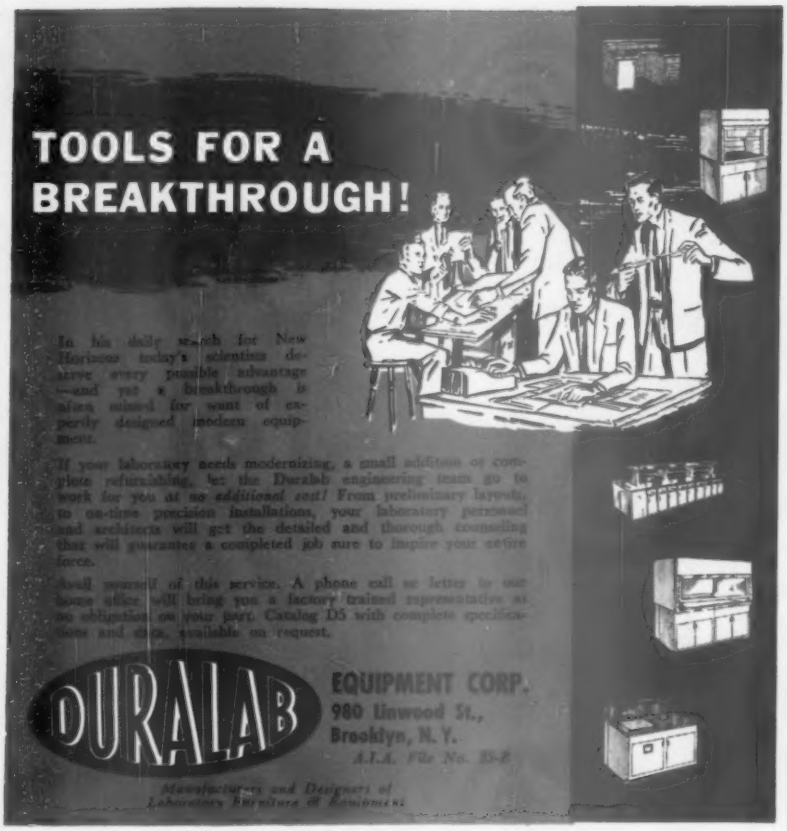
446G

For detailed description and specifications of Alite, write for FREE Bulletins A-7R and A-40.

ALITE DIVISION

U. S. STONEWARE

BOX 119 ORRVILLE, OHIO



MINIATURE PANEL METERS THAT DO A BIG JOB!

Available in a wide variety of standard ranges and with special scales, ranges, sensitivities, resistances, cases and other modifications to your special requirements. Illuminated models can also be supplied.

Particularly suited for portable, marine, airborne, geophysical and military communications, testing and control equipment where space is at a premium and performance cannot be sacrificed.

PARTIAL SPECIFICATIONS

	1" Models	1½" Models	1½" Ruggedized
Weight	1 oz.	4 oz.	4.2 oz.
Accuracy	± 3% of full scale for DC; ± 5% of full scale for AC		
Scale Length	.760"	1.322"	1.0"

Available as DCUA, DCMA, DCA, DCMV, DCV, ACV, with zero at center, left or right. Also VU and Db meters.

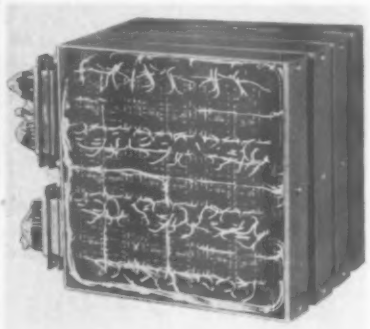
WRITE FOR ENGINEERING DATA SHEETS on our complete line of panel meters, side indicators, Electronic Control Meters, miniature multitesters.

miniaturization headquarters
international instruments inc.
88 Marsh Hill Road, Orange, Conn., Cable: "INTERINST"

Products and Materials

Department starts on page 123

a dangerous radiation dose. NUMEC puts out two monitors—PRM-1 that is most effective for 1 mr/hr to 2 r/hr dose rates and PRM-2 that works best from 10 mr/hr to 200 r/hr. Range of ambient temperature operation for NUMEC monitors is from −20 to +120°F. Landsverk and AA monitors can be shut off by laying them on their side or tipping them upside down; thus its battery life can be saved. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, O.; Radiation Equipment and Accessories Corp., 665 Merrick Rd., Lynbrook, N. Y.; Nuclear Materials and Equipment Corp., Apollo, Pa.; Atomic Accessories, Inc., 811 W. Merrick Rd., Valley Stream, N. Y.; Landsverk Electrometer Co., Glendale, Calif.



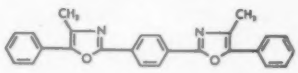
Pulse-height analyzer for space. To measure, accumulate and code signals from radiation detectors in satellites or space probes, RIDL has developed Model 34-13, 32-channel analyzer (above). Miniature instrument stores data in ferrite core memory for short or extended time periods. Analyzer can be programmed for single or repeated digital readout to a telemetering system; data can then be cleared from memory and new cycle started. Storage capacity is 65,535 counts, resolution 3% of full scale.—Radiation Instrument Development Laboratory, 61 E. North Ave., Northlake, Ill.

Budget pulse-height analyzer. 256-channel pulse-height analyzer costs only $4950, has channel capacity of 65,535 counts, average dead time of 38.1 μsec, rise and fall times of 0.6 μsec, differential linearity better than ±2% from channel 3 to 255, integral linearity 0.5% for same channel range. 128-channel analyzer also available.—Radiation Counter Laboratories, Inc., 5121 W. Grove St., Skokie, Ill.

ARAPAHOE
TRADE-MARK

NEW
SCINTILLATOR

Dimethyl-POPOP



For Liquid Scintillation Counting

Even better than POPOP!

- IMPROVED BAND-SHIFTER
  Fl. Max. 120 A longer than POPOP
- BETTER SOLUBILITY
  Over 3 times that of POPOP
- EXCELLENT PULSE HEIGHT
  Identical with POPOP
- REASONABLY PRICED
  Same price as POPOP

Dimethyl-POPOP is a product of Arapahoe's increasing research effort. Write Dept. "K" for Data Sheet and further information.

ARAPAHOE CHEMICALS, INC.
BOULDER, COLORADO
PRODUCERS OF FINE ORGANIC CHEMICALS

"That's nothing new. My husband read that three weeks ago in NUCLEONICS WEEK."

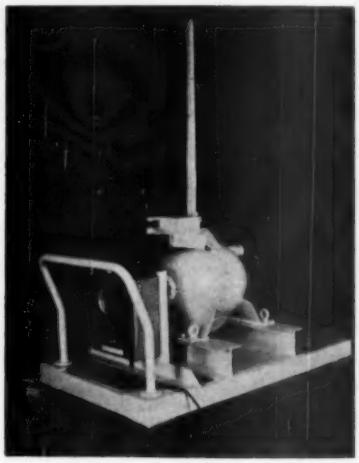
The only way you can evaluate NUCLEONICS WEEK is by reading it. Write for a 4-week complimentary subscription.

Make a date this week with . . .

NUCLEONICS WEEK 330 WEST 42nd ST., NEW YORK 36, N.Y.

Whole-body counter (above) with 2-π geometry measures small levels of gamma radiation from humans, animals or samples weighing up to 500 lb. Sample is slid in tray through passage in 6-in.-thick steel shielding to counter system where scintillators can count K^{40} in adults in 100 sec with an accuracy of $\sim \pm 3\%$. Resolution for K^{40} is $\sim 25\%$ with an absolute efficiency of 21%.—Metrix Inc., P. O. Box 223, Deerfield, Ill.

Noble-metal thermocouple. For reactors in which operating temperatures restrict lives of base-metal thermocouples, Platinel, made of gold, palladium and platinum resists oxidation and reduces maintenance costs. Initial tests show drift of 2 deg in emf output after 2,500 hr test at 1,300°C.—Engelhard Industries, Inc., 850 Passaic Ave., E. Newark, N. J.



Co^{60} irradiator (above), originally designed for irradiating 1¼-in.-diameter dosimeter badges loaded through top of machine, can be altered for other types of products that must be individually irradiated in large quantities. Irradiator uses 20 curies of Co^{60}.—Radiation Products Inc., 40th Rd., Flushing 52, N. Y. (*Continued*)

GRAY BIMETALLIC PIPE PROVIDES CORROSION RESISTANCE AT FRACTION OF THE COST OF SOLID ALLOY SYSTEMS

Gray Bimetallic pipe provides all the fabrication and strength advantages of carbon steel with the corrosion resistance of the best alloy materials, and at a fraction of the cost of a solid alloy system.

In the Gray process, a seamless lining is hydraulically expanded into the base pipe, forming a tight bond due to differential contraction of the materials. For all practical purposes the bond is permanent. Bimetallic pipe can then be fabricated almost as easily as carbon steel. It can be butt welded, flanged and bent without damage to the lining or the bond.

The choice of materials for Bimetallic pipe is virtually unlimited. Base material is usually standard carbon steel in regular sizes and schedules, but this can be varied to meet any particular need. Linings are most frequently furnished in Monel, nickel and stainless steel, but the selection is in no way limited. All the alloys of nickel and copper as well as the reactive metals can be economically produced.

This wide range of materials available make Bimetallic pipe ideal for all applications where corrosion is a factor. It is well suited where product contamination or catalyst poisoning are problems.

Gray Bimetallic pipe provides the corrosion resistance of special alloys at only a small cost more than that of regular carbon steel piping. For complete details, mail the coupon below today!

GRAY Tool Company

P. O. Box 2291 • Houston 1, Texas

Gray Tool Company
P. O. Box 2291
Houston 1, Texas

Gentlemen:
Please send me more information about Gray Bimetallic pipe.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

6114

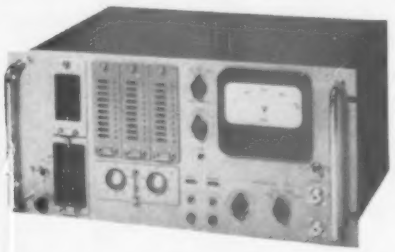
Two Bell Telephone instruments, a high-voltage supply for G-M tubes (NUK-164-A1) and a Programmator (NUK-181-A1), are now available. High-voltage supply gives outputs of 250–500, 500–1,000 and 750–1,500 volts continuously variable and has stability of better than 0.1%. Plug-in Programmator allows automatic counting, printing and sample changing of radioactive samples with both preset time and preset count methods. Unit has counting time interval of 10^{-2} sec minimum and interruption of 10^{-2} minimum. Ratio of interruption to counting ranges is from 10^{-5} to 10^{5}.—Bell Telephone Manufacturing Co., Berkenrodelei, Hoboken-Antwerp, Belgium.

SOCIETE D'APPLICATIONS INDUSTRIELLES DE LA PHYSIQUE

NEW ALL SOLID STATE DECIMAL SCALERS UP TO 10 Mc/sec

MODEL ECH 6 T

- 6 interchangeable decades
- Scaler resolution: 1 μs or 0.1 μs
- Storage: 10^6 counts
- Optional mechanical register
- Stop at preset count
- Input polarity: negative or positive by a switch
- A gate is provided to start or stop
- Reset possible by external pulse



MODEL ECG 3 T

- Scaler for Geiger-Müller or scintillation counting
- High voltage adjustable from 200 to 2,000 Volts
  Stability 5/10,000 for 10% line variation
- Storage: 10^7 counts 3 decades plus a mechanical register
- Resolution of the scaler: 2 μsec
- Two operating ways: preset count from 10 to 10^7 counts
  preset time: 1 second to 2 hours

S.A.I.P. /38, rue Gabriel Crié-MALAKOFF (Seine) FRANCE

Tel: ALEsia 87-20 + Telegram, SAIPHY-MALAKOFF

Four-in-one beta counting system (above), developed by Transnuclear Corp., combines four detector units, each with sample holder, sample detector, guard detector and scaler, into one counting system with transistors.—Nuclear Industries, 10 Holland Court, Valley Stream, N. Y.

Control center for Plum Brook reactor is completely instrumented by Leeds & Northrup Co. Equipment (above) includes a thermal computer for measuring reactor power output; in addition, electric proportioning devices will automatically control rate of change of reaction and intensity of power level in reactor.—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Scintillation-well counter, Model 90-2, can detect 10^{-10} curies of K^{40} during a 20 min count. Weighing 4,500 lb, detector consists of a plastic scintillation-well counter, 24 in. high, 12 in. in diameter, with 2-in. wall thicknesses. Five inches of steel shield detector.—Franklin Systems, Inc., 2734 Hillsboro Rd., W. Palm Beach, Fla. (*Continued*)

Pu: Be

neutron sources for

GREATER SAFETY

low extraneous radiation
proven source design
double encapsulation
special hi-integrity welds

MOBILITY & FLEXIBILITY

low gamma radiation
less shield, weight, space
wider range of application

LOWER COSTS

Total costs for either purchase or rental use of NUMEC Pu:Be neutron sources less than rental price of comparable Ra:Be sources.
Ease of calibration due to constant neutron emission – savings in time and money.

NUMEC standard Pu:Be sources include 1, 2, 3, 4, 5, 7 and 10 curie sizes.

ALPHA, BETA, GAMMA, and other NEUTRON sources also available.

NUMEC®

NUCLEAR MATERIALS AND EQUIPMENT CORPORATION
APOLLO, P. A. PHONE GR 2-8411
TWX APO 276 CABLE NUMEC

FOR THOSE

EXPOSED TO RADIOACTIVITY

DISCOVER THE IMPORTANT PERSONALIZED MEASURES WE TAKE TO PROTECT YOUR PERSONNEL WITH THESE VITAL SERVICES.

film badge service...	**GAMMA - BETA - X-RAY - NEUTRON**
bio-Assay service...	**ROUTINE URINALYSIS - WIPE TESTS AIR - SOIL - WATER - VEGETATION**
calibration service...	**FOR SURVEY & SIMILAR INSTRUMENTS CERTIFICATE ISSUED.**

For full details without obligation mail coupon today to—

ATOMIC FILM BADGE CORPORATION

ATOMIC FILM BADGE CORPORATION **BIO ASSAY INC.,**
11-20 46th Road, Long Island City, N. Y.

SEND INFORMATION FOR...

☐ Film Badge Service ☐ Bio-Assay Service ☐ Calibration Service

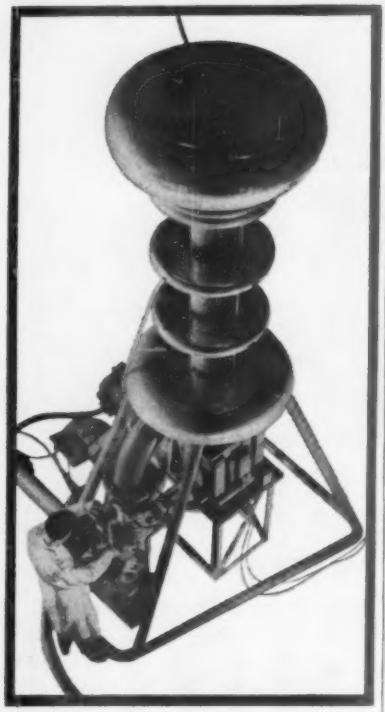
NAME_____

ADDRESS_____

CITY_____ STATE_____

Sames

ELECTROSTATIC
PARTICLE ACCELERATORS



These provide a wide range of particles and radiations:

Electrons—Protons—Neutrons—Deuterons—X-Rays.

- Voltages to 600 KV, infinitely variable
- Current to 4 ma
- Stability to ±.01%
- Ion current (Protons or Deuterons) to 0.6 ma continuous
- Electronic beam current to 3 ma continuous
- X-Rays to 1000 Roentgens/sec
- Beam diameters adjustable, 2 to 10 mm
- Beam pulsing available, 10 to 200 μs

Maximum Safety: Low internal capacitance. Minimal short circuit currents. Remote adjustment and shut down.

• *Write for literature*

Sames

30 Broad Street, Rm. 3702
New York 4, N.Y.

Products and Materials

Department starts on page 123

Bellows seal valves 473 series, with forged stainless-steel valve bodies and inert-arc welded-bellows assemblies control rare and dangerous fluids at temperatures up to 600°F and pressures up to 2,000 psi.—Hoke Inc., 1 Tenakill Park, Cresskill, N. J.

E-302 Electrometer for nuclear applications has coarse and fine zero adjustment, stability of 0.01%, 1 to 3 ratio in decades, response time 10 times faster than previous models, outputs of 1–50 Mv and accuracy of 2%.—Gyra Electronics Corp., Washington and Elm St., La Grange, Ill.

LITERATURE AVAILABLE

Foote Lithium Chemicals. 4 pp.; Foote Mineral Co., 18 W. Chelten Ave., Philadelphia 44, Pa.

Nuclear-Data General Catalog. 22 pp.; Nuclear Data, 3833 W. Beltine Highway, Madison, Wisc.

Experimental Manual for Reactor Simulator. Single copy price $5.00; Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Gamma-matic Sample Changer. 2 pp.; Sharp Laboratories, Box 1302, La Jolla, Calif.

Transistorized Instruments. 6 pp.; Packard Instrument Co., Box 428, La Grange, Ill.

Low-Level Beta Counting Systems. 2 pp.; Transnuclear Corp., 120 Woodland Ave., Westwood, N. J.

Multiple Coincidence Unit. 2 pp.; Cosmic Radiation Labs, Inc., Bellport, N. Y.

Recording Oscillograph. 4 pp.; Consolidated Electrodynamics, 360 Sierra Madra Villa, Pasadena, Calif.

DC to 1000 Megacycles Oscilloscope. 8 pp.; Tektronix, Inc., Box 500, Beaverton, Ore.

Dajac LABORATORIES

SCINTILLATORS

- Polyphors®—polystyrene or polyvinyl toluene
- Loaded liquid Scintillators
- PYP-1* and standard waveshifters
- Scintillation grade fluors
- Available in all sizes and shapes up to 5′ x 5′ x 1′

*Patent Pending

Write for Data Sheet today.

THE Borden CHEMICAL COMPANY
3000 LANGDON STREET • P. O. BOX 9522
PHILADELPHIA 24, PA.

WHERE TO BUY

TRITIATED TITANIUM FOIL
as beam target in neutron generators, ion producer (gas chromatography, static eliminators, vacuum gauges ionization tubes). Tritium content: approximately 1 curie/in.² (or to requirements). Backing: 2 mil stainless . . . other metals and thicknesses available on special order. Also DEUTERATED TARGETS. ADDRESS INQUIRIES TO
RADIATION RESEARCH CORPORATION
1150 Shames Drive
Westbury Industrial Park, Westbury, N.Y.
"First in Nuclear Batteries"

NEUTRON Shielding Windows

Announcing: Gadolinium glass originated by Penberthy. Gadolinium glass permits direct viewing with mixed neutron and gamma radiation.

PENBERTHY INSTRUMENT CO.
6701 Maynard Ave., Seattle 8, Wash.
PArkway 5-5400

JERPBAK BAYLESS

34150 Solon Rd.
Cleveland 39, Ohio

analytical
& metallurgical
services

Analytical Services:

- Analyses of gasses in metals
- BET surface area measurements
- Rare earth analyses
- Optical emission, X-ray fluorescence, X-ray diffraction spectroscopy
- Uranium isotopic assays
- Wet chemical analyses
- Powder characterization
- Thermogravimetric analyses

Metallurgical Services:

- Metallography
- Tensile, fatigue, hardness, impact and burst testing
- Leak detection
- Corrosion testing

Other NUMEC SERVICES include: Vacuum and inert atmospheric arc and induction melting. Recovery of precious metals. Consulting and R&D services. Unirradiated nuclear fuel scrap recovery.

For information and prices contact:

NUMEC®

NUCLEAR MATERIALS AND EQUIPMENT CORPORATION
APOLLO, P. A. PHONE GR 7-8411
TWX APO 276 CABLE NUMEC

NUCLEONIC INSTRUMENTS

- **Universal Transistorized Radiation Monitor.** A Scintillation Detector, 2½ lbs in weight, versatile, suitable for Industrial, Health-Physics, or Civil Defence applications.
- **Series 1001 Transcint.** Transistorized scintillation counter for measurement of all radiation by interchangeable detectors. The instrument has a pistol-probe and is powered by four standard flashlight cells with 400 hours of operation. A pulse output jack is provided for headphones or an external scaler.
- **Model 963-T Transcint.** Transistorized as above. For measurement of fast or slow neutrons and gamma rays.
- **Series 1020 Air Sampler.** To facilitate rapid field measurements of airborne radon daughter products. A filter holder accommodates a standard molecular membrane filter. Operates from a 6 volt battery. Used in association with the Transcint 1001 to measure alpha activity on the filter.
- **Radioisotope Analyzer.** Designed to enable the user to quickly check the identity of a radioisotope and also to measure its activity. It is used with those isotopes which emit gamma rays.

SCINTILLATION PHOSPHORS

- **NE 102 Plastic Phosphor** in rods, slabs and sheets, filaments and capillary form. Any size or shape.
- **NE 421 Thermal Neutron Detector.** Enriched 96% Lithium-6 in this detector provides high detection efficiency combined with excellent discrimination against gamma background.
- **NE 160 High Temperature Plastic Phosphor.** For scintillation measurement at temperatures over 100°C.
- **High Flash Point Scintillators.** For safe, economical, giant liquid scintillator installations.
- **Liquid and Plastic Scintillators.** For the challenging technique of Pulse Shape Discrimination.
- **NE 814 Scintillating Vials.** For convenient counting of aqueous samples.
- **"Scinstant" Scintillators.** Premixed solute combinations for convenient dependable preparation of liquid scintillators for internal counting.

Ten years of experience in producing the finest detectors. Any size—any shape—to your custom requirements, with matched photomultiplier tubes and electronic circuitry.

Enquiries invited. New catalogue available.

NUCLEAR ENTERPRISES LTD.

550 BERRY STREET
WINNIPEG 21, CANADA

Associate Co: Nuclear Enterprises (G.B.) Ltd.
Edinburgh, Scotland

Ekco Type N664
scintillation counter
and N610 automatic
scaler provide a stable and accurate system for the assay of low energy Beta emitters in the liquid state, particularly Carbon 14 and Tritium.
N664 is a shielded bench-standing scintillation counter incorporating the sample phosphor liquid technique. The design provides optimum geometry and ready access for sample changing. Specific activities down to 10-10 curies per millilitre can be assayed and counting efficiencies in excess of 40% can be achieved with tritiated water samples at 15 cps background.
N610 is a combined automatic scaler and timer with an inbuilt ratemeter, pulse height analyser, amplifier and stabilised H.V. supply. The P.H.A. used with the inbuilt ratemeter provides rapid identification of energies and permits assay of Double Labelled samples. The P.H.A. is also ideal for background reduction. In an alternative arrangement it is useful for the simultaneous assay of Double Labelled samples, the timer can be used as a second scaler channel, taking an output from the upper discriminator of the P.H.A.

EKCO *Electronics Ltd.*
Southend-on-Sea, England.
In U.S.A. contact associate company:
American Tradair Corporation, 34-01 30th Street, Long Island City 6, New York.

Products and Materials

Department starts on page 123

Nuclear Gaging Systems, 4 pp.; Ohmart Corp., 2236 Bogen St., Cincinnati 22, O.

Condensed Catalog of Vacuum Products. 12 pp.; Varian Associates, Palo Alto, Calif.

Insulating-Core Transformer. 1 p.; High Voltage Engineering Corp., Burlington, Mass.

DC Power Supplies. 30 pp.; Kepco, Inc., 131-38 Sanford Ave., Flushing 52, N. Y.

High-Integrity Castings. 6 pp.; Lebanon Steel Foundry, Lebanon, Pa.

Application Data for Non-Corrosive Metals.; Dept. C-1, Waukesha Foundry Co., Waukesha, Wis.

Corrosion Data Charts. 6 pp.; Nooter Technical Service, 1400 S. Third St., St. Louis 66, Mo.

Low-Background Beta-Counting Systems. 4 pp.; **Tracerlab Environmental Survey and Analytical Service.** 1 p.; **Subsieve Size Radioactive Particle Analysis.** 1 p.; **Radium-226 and Radon-222 Analysis.** 1 p.; Tracerlab, 1601 Trapelo Rd., Waltham 54, Mass.

Ionization Chamber. 1 p.; Reactor Controls Co., Box 427, Oak Ridge, Tenn.

Services in Research. 68 pp.; Isotopes, Inc., 123 Woodland Ave., Westwood, N. J.

Company History, Capabilities and Products. 22 pp.; Edgerton, Germeshausen & Grier, Inc., 160 Brookline Ave., Boston 15, Mass.

Nuclear Space Automatic Handling Equipment. 24 pp.; General Mills, 419 N. Fifth St., Minneapolis 1, Minn.

ML-1 A Mobile Nuclear Power Plant. 12 pp.; Aerojet-General Nucleonics, P. O. Box 77, San Ramon, Calif.

Services to the Nuclear Industry. 12 pp.; Vitro Engineering Co., 225 Park Ave. S., New York 3, N. Y.

Nuclear Physicist

Senior Physicist with at least 5 years' experience in the use and design of "systems" for the detection of low level radiation. In general, the primary responsibility of this Physicist will be the design and specification of the front end of nuclear systems and instruments. In addition, he will spend a large percentage of his time looking into and evaluating new developments in the nuclear physics field, in order to consider these for possible influence and applications to our product line.

Senior Circuit Designer

Senior Engineer with approximately 5 years' circuit design experience. He will be concerned with the development of circuitry for our nuclear instrument line and will be responsible for technical specifications, design and comparative studies of currently available commercial instrumentation. Therefore, experience in commercial circuit development where cost is a basic consideration is highly desirable. We would prefer a man with experience in the nuclear instrument field but related experience in high frequency amplifiers, pulse, analog and transistor circuitry would be considered.

It is our hope that these two men will plan an important part in the future of our commercial instrument line. Thus, we are seeking technical people with a high degree of maturity and combined interests in the practical and theoretical.

Equally interesting and challenging positions are available for:

- Optical Physicists and Engineers
- Infrared Physicists and Engineers
- Geophysicists

These positions offer excellent starting salaries and participation in the employee benefit program which includes profit sharing.

Please submit resume to:

MR. HERBERT ARONSON
Chief Engineer,
Instrument Laboratory

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

BAIRD-ATOMIC, Inc.
33 University Rd.
Cambridge 38, Mass.

DEPENDABILITY IN RADIOCHEMICALS

Processing laboratories at Amersham.

RADIOISOTOPE INSTRUMENTATION in workshop and laboratory

As position indicators, density and level gauges in enclosed pipes or tanks, or even at the coal face, instruments containing small gamma-ray sources are proving immensely valuable to a variety of industries. Caesium-137 has a conveniently long half-life (27 years), the sources needed are small and shielding requirements relatively modest, so that the instrument need not be bulky or cumbersome. Suitable sources containing 1-500 mc caesium-137 in small sealed pellets can be obtained from the Radiochemical Centre.

Thickness measurement or continuous control of sheet materials or surface coatings, and rapid analysis of certain alloys can be carried out with promethium bremsstrahlung sources. The radioisotope is surrounded by an aluminium target to produce bremsstrahlung and characteristic X-radiation, with a useful energy range of 12-45 keV. This method makes use of a source that is cheap, stable and readily available. The Radiochemical Centre will gladly provide further details on request.

Comprehensive catalogues are available on application.

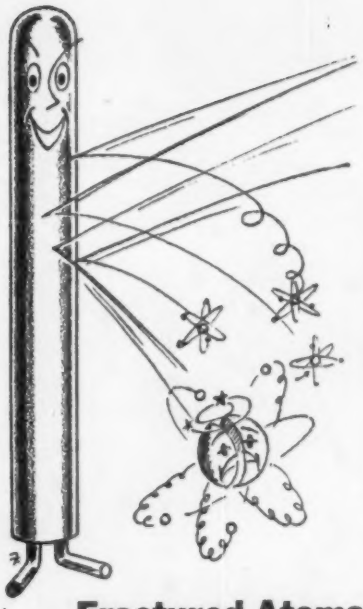
Enquiries for all radioactive supplies and services to:—

THE RADIOCHEMICAL CENTRE

AMERSHAM, BUCKINGHAMSHIRE, ENGLAND

World centre for dependable radiochemicals

Telephone: Little Chalfont 2701 *Cables: Activity, Amersham, Telex*
Telex: Active, Amersham 83141



Fractured Atoms Bounce off Ceramo® Thermocouples

We Ceramo Thermocouples are not annoyed by high heat and radiation of fractured atoms. Specified, time and time again, for temperature measurement in all types of military and industrial atomic reactors, Ceramo Thermocouples have proven highly reliable, stable, sensitive and long-lived. We can be formed to almost any configuration without damage, and withstand higher temperatures, radiation, contaminating environments and mechanical strain without changing electrical or mechanical characteristics. When you must be sure, specify CERAMO, the original metal-sheathed, ceramic-insulated thermocouple wire.

Write today for your THERMOCOUPLE CATALOG TC-26 More than 48 pages of profitable information on every type of Thermo Electric Thermocouple.

20 YEARS

Thermo Electric

Temperature Measuring Systems and Components

THERMO ELECTRIC Co., Inc., Saddle Brook, N. J.
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

NEWSMAKERS

Maurice Goldhaber has been appointed director of Brookhaven National Laboratory succeeding Leland J. Haworth who left in April to become a member of the Atomic Energy Commission. **G. F. Tape,** who has been acting director since April, will serve as deputy director. Goldhaber has been in the physics dept. of Brookhaven since 1950—two years as chairman. Previously he had served on the faculty of the Univ. of Illinois and as a consultant to the Argonne National Laboratory. He has been active as both an experimental and a theoretical physicist, specializing at Brookhaven in the study of isomers and fundamental particles.

Goldhaber

R. L. Mela has joined the Dynatech Corp., Cambridge, as manager of military systems. He had previously been assistant to the director of the SNAP (Systems for Nuclear Auxiliary Power) program at Atomics International.

John P. Maurer has joined Astra, Inc., Raleigh, N. C., as an associate. He has worked with both ACF Industries and Bechtel Corp. where he has had responsibility for design, specification, and assembly of test equipment for the turret reactor as well as design responsibilities for nuclear rocket and Tory IIA nuclear ramjet components.

Maurer

Robert L. Deming has been appointed manager of engineering and development at the Tracerlab Reactor Monitoring Center, Richmond, Calif. He has previously held managerial positions in research, engineering and marketing with the General Dynamics/Electronics div. of General Dynamics Corp. and has served as a senior research staff member at Los Alamos Scientific Laboratory.

William R. Bush will head the United Nuclear Corp.'s newly-established Washington office as assistant to the president. **Walter A. Hamilton,** formerly vice president of Nuclear Development Corp. of America, has been named director of public affairs for United Nuclear.

R. Murph Jones has been named to the new position of marketing director at Petrolite Corp., St. Louis. He had previously been assistant manager of Lockheed Aircraft Corp.'s Nuclear Branch in Georgia. He will be responsible for Petrolite's marketing activities in the petroleum, chemical and nuclear fields.

Jones

Giacomo Bertolotti has been issued the first license granted to a foreign national to operate a nuclear power plant in the U. S. Bertolotti is presently on assignment to the Westinghouse Atomic Power dept. where he is assisting in preparation of the operating manual for the SELNI Enrico Fermi atomic plant for which he will supervise operations.

Samuel Koslov has been appointed assistant head of the dept. of physics and space sciences at Vitro Laboratories in West Orange, N. J. Before joining Vitro, he had been assistant head of the physics dept. at Stevens Institute of Technology and a member of the technical staff of Bell Laboratories' Electron Tube Development div. In his new position Koslov will conduct research in the nuclear and plasma fields.

William R. Anderson has been appointed special research assistant to the president of Landsverk Electrometer Co., Glendale, Calif.

Floyd P. Trent has recently been promoted to manager of AEC's Puerto Rico Area Office which administers the contracts for the Puerto Rico Nuclear Center and the BONUS reactor under construction at Rincon, Puerto Rico. Trent was previously director of the ORNL supply div. Robert H. Miller, deputy director under Trent, will succeed him as director.

NUCLEAR CALENDAR

September 3–8—140th Meeting of American Chemical Society, including symposium on nuclear technology, Chicago; contact: A. T. Windstead, National Meetings Dept., ACS, 1155 16th St., N.W., Washington 6, D. C.

September 4–9—International Conference on Low-Energy Nuclear Physics, sponsored by International Union of Pure and Applied Physics, Manchester; contact: B. H. Flowers, Manchester U., Manchester 13, Eng.

September 5–12—2nd International Conference on High Energy Accelerators and Instrumentation, sponsored by the Commission on High Energy Physics of the International Union for Pure and Applied Sciences, Brookhaven National Lab., Upton, N. Y. Contact Prof. P. Fleury, Institut d'Optique, 3, Blvd. Pasteur, Paris.

September 6–8—Nuclear Instrumentation Symposium sponsored jointly by ISA, AIEE, IRE; North Carolina State College, Raleigh, N. C. Contact ISA Meetings Manager, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

September 6–9—Meeting of the American Physical Society, Seattle, Wash. Contact W. A. Nierenberg, Univ. of California, Berkeley 4, Calif.

September 25–28—American Welding Society fall meeting, Dallas, Texas (*Adolphus*); includes papers on reactor fabrication. Contact A. L. Phillips, AWS, 33 W. 39 St., New York 18, N. Y.

October 9–15—American Rocket Society 1961 Space Flight Report to the Nation, New York (*Coliseum*); papers and exhibits reviewing major technical work in rocketry, missiles and space flight. Contact Roderick L. Hohl, Public Relations Mgr., ARS, 500 Fifth Ave., New York 36, N. Y.

October 20—Fifth annual symposium on Advances in Tracer Methodology sponsored by New England Nuclear Corp., Washington, D. C. (*Shoreham*); review and discussions on use of radioisotopic tracers. Contact Paul A. McNulty, New England Nuclear Corp., 575 Albany St., Boston 18, Mass.

October 23–26—International Symposium on Aero-Space Nuclear Propulsion, jointly sponsored by AEC, NASA, and the IRE PGNS, including review of SNAP, Rover and Pluto programs, Las Vegas, Nev.; contact: D. J. Niehaus, The Bendix Corp., Detroit, Mich.

EXCELLENT CAREER OPPORTUNITIES!

Expanded Allis-Chalmers program has created these challenging new nuclear power job openings:

(Greendale Labs-Milwaukee and Washington, D. C. locations)

• HEAT TRANSFER SPECIALIST

Duties will include design study, analysis and experimental work on Boiling Water and Superheated Steam Reactors. Applicant should have a minimum of three years experience in this field . . . including: design and performance analysis; familiarity with experimental techniques; engineering application of test results.

• ENGINEERS

Instrumentation and Control . . . Electrical Engineer with three to five years experience in reactor instrumentation and control systems.

Core Design . . . BSME with five to ten years experience in the nuclear field and in the design of reactor cores and related components.

Process . . . BSME or BS Chemical Engineering with three to five years experience to prepare flow diagrams and handle water chemistry, water activation, and waste disposal problems.

Operations Engineer . . . Minimum of three years reactor experience, preferably some power reactor background . . . for checkout and operation of reactor and associated systems.

RESUME SHOULD INCLUDE:
experience, education, salary range, and other pertinent details. Replies held in strict confidence. All inquiries answered.

SEND REPLIES TO:
JOHN C. SCHROEDER
Department 1621
Allis-Chalmers
Milwaukee 1, Wisconsin

ALL QUALIFIED APPLICANTS WILL RECEIVE CONSIDERATION FOR EMPLOYMENT WITHOUT REGARD TO RACE, CREED, COLOR, OR NATIONAL ORIGIN.

ALLIS-CHALMERS

EDITOR WANTED . . . . . .

To write about the exciting field of nuclear technology we need a

- scientist or engineer who has
- nuclear experience and is willing to
- learn to write

If you think you might meet the challenge and would like to try, send resume and salary requirements to

The Editor
NUCLEONICS
McGraw-Hill Building
330 West 42nd Street
New York 36, N. Y.

SCIENTISTS AND ENGINEERS ARE NEEDED AT AMF ATOMICS

IMMEDIATE OPENINGS AT ALL LEVELS

Large New Programs in Remote Handling Systems and Reactor Development
Have Created the Following Requirements:

MECHANICAL ENGINEERS for complex nuclear handling equipment projects. Machine design, shop practice, hydraulics, fluid flow, heat transfer experience desirable. Knowledge of shielding and radiation effects helpful.

PROJECT ENGINEERS experienced in leading reactor projects and facility studies. Must be capable of planning and controlling costs and schedules, dealing with customers, coordinating other groups. Mechanical or civil background.

PROCESS ENGINEERS for planning, organizing, and controlling liquid metal projects. Responsible for costs, schedules, and customer liaison. Experience in project work and liquid metals.

ELECTRICAL ENGINEERS with experience in motor controls, power distribution and servo systems. Must have good working knowledge of commercial equipment. Familiarity with radiation effects desirable.

NUCLEAR ENGINEERS to lead advanced reactor projects. Requires ORSORT training or equivalent, and broad background in reactor design and construction or operation. Strength in core physics or thermodynamics.

PHYSICISTS to supervise reactor test programs. Requires advanced degree or equivalent on-the-job training and experience in reactor physics, shielding, and experimental work.

Contact: Personnel Department

AMF ATOMICS

A Division of American Machine & Foundry Company

140 Greenwich Avenue, Greenwich, Connecticut

Experience, performance across the board . . . across the world

All qualified applicants will be considered regardless of race, creed, color or national origin.

APPLIED RADIATION ENGINEERING RESEARCH

Chemonuclear Processing

Principal programs at our new Nuclear Research Center at Tuxedo, New York (40 miles northwest of New York City) involve the use of a 5 megawatt research reactor for the development of special nuclear fuels, optimizing radiation chemistry processes, product decontamination and varied economic evaluations.

Excellent opportunities for BS, MS or PhD personnel, with up to 6 years' experience in chemical development, unit operations or pilot plant work.

Send resume with salary requirements to:

UNION CARBIDE NUCLEAR CO.

P.O. Box 324-R, Tuxedo, New York

A Division of Union Carbide Corporation

UNION CARBIDE

All qualified candidates will continue to receive consideration for employment, without regard to race, creed, color or national origin.

for **POSITIONS** in the **NUCLEAR FIELD...**

WRITE US FIRST!
Use Our Application
No Resume Required

Our national coverage and technical experience in the nuclear field offers the maximum opportunity to achieve your goals.

Confidential Handling
Employer Pays Fee

Write: Arthur L. Krasnow

ATOMIC PERSONNEL, INC.

1518 Walnut St. • Phila. 2, Pa. • PE 5-4908
An Employment Agency for the Nuclear Field

VACUUM ENGINEER

Central Scientific Company, recognized leader in scientific apparatus, offers a career position for a graduate engineer or physicist with a minimum of 3 years' experience in research involving vacuum pumps and systems.
Duties will include design and development of vacuum pumps, systems, gauges and accessories. This position offers a wide variety of problems in a field which is rapidly expanding.
Salary is competitive and employee benefits most liberal.
Please send complete resume to:

E. A. SUPRINSKI
Industrial Relations Manager
CENTRAL SCIENTIFIC COMPANY
1700 West Irving Park Road
Chicago 13, Illinois

POSITION WANTED

Man with experience in setting up and managing radioisotope laboratory for well known electronic equipment manufacturer wishes to relocate on East or West Coast. Reply: PW-6917, Nucleonics, Classified Adv. Div., P.O. Box 12, New York 36, N.Y.

DESIGN ENGINEERS

Senior

Must have extensive experience in transistorized circuit design of:

MULTICHANNEL PULSE-HEIGHT ANALYZERS

DIGITAL DATA HANDLING

NUCLEAR INSTRUMENTATION

Send Resume to:

TULLAMORE ELECTRONICS CORP.
6726 S. Ashland Ave.
Chicago 36, Ill.
Phone—Pr. 8-4700

PROFESSIONAL SERVICES

ASTRA, INC.
Consultants For Industry & Government
Nuclear: Nuclear Analysis, Reactor Specifications & Design, Shielding, Health Physics, Criticality Hazards Studies
Space: Radiation Effects, Propulsion, Satellite Power Plants, Planetary Simulators
Advanced Technology: Heat Transfer, Stress Aanalysis, Thermodynamics, Electronic Data Processing, Cryogenics
Raleigh N. C. VAnce 8-4386 Cable: "ASTRA"

THE KNOLLS ATOMIC POWER LABORATORY

...Where Achievements in Research Are Applied Today... And Developed Into Tomorrow's Nuclear Systems...

Selective program expansion—and commencement of applied research and development projects in new and promising areas of nuclear reactor and power plant technology—have generated several new openings of unusual potential at KAPL.

Positions are immediately available in:

Theoretical Physics (PhD)
Experimental Physics (PhD)
Coolant Technology
Welding Development
Thermal and Hydraulic Design
Fluid Systems

Forward your resume in confidence to Mr. G. L. Smallwood, Dept. 48-MI

U. S. Citizenship Required. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Knolls Atomic Power Laboratory
OPERATED FOR A E C BY
GENERAL ELECTRIC
Schenectady, New York

RADIOISOTOPE SERVICES

Technical Coordinator

●B.S. in Engineering, Chemistry, Physics or Life Sciences and one to three years' experience in health physics, radio chemistry or radio biology. Duties will involve liaison between the various research groups in a large nuclear research laboratory and the laboratory's Health Chemistry Department. This department furnishes an integrated package of engineering, monitoring, ventilation, transportation, and waste disposal services for safe handling of radioisotopes.

U. S. CITIZENSHIP REQUIRED

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Please send confidential resume to
MR. W. F. KANE

LAWRENCE RADIATION LABORATORY
Berkeley, California

THE ISRAEL ATOMIC ENERGY COMMISSION OFFERS A NUMBER OF FELLOWSHIPS FOR THE ACADEMIC YEAR 1962–1963

These fellowships are intended for scientists with several years of post doctoral research experience as well as experience in leading a research group. It is expected that the candidate will have worked for several years in one of the following fields:

Nuclear Physics
Solid State Physics
Nuclear and Radiochemistry
Radioisotope Research and Production
Radiation Chemistry and Radiobiology
Medical and Industrial applications of Radioisotopes

The selected candidates will work at the Israel Atomic Energy Commission Laboratories near Rehovot and will have at their disposal the facilities of the Centre, including a 5 MW Swimming Pool Reactor.

The stipend includes round trip fare by air or ship for the scientist and his family and an adequate living allowance in Israel in local currency.

Living quarters will be made available by the I.A.E.C.

Applications and inquiries should be sent to the following address:

Personnel Department
P.O.B. 527 Rehovot
Israel

EMPLOYMENT PROBLEM?

When you are in need of specialized men for specialized jobs, contact them through an employment ad in this publication.

INDEX TO ADVERTISERS

* AMF Atomics, A Division of American Machine & Foundry Co..34, 35
* American Smelting & Refining Co., Federated Metals Division..40, 41
* American Tradair Corp., Ekco Electronics Ltd.....132
* Arapahoe Chemicals, Inc.....127
* Atomic Accessories, Inc., Subsidiary of Baird-Atomic, Inc.... 90
Atomic Film Badge Corp.....129
* Atomics International, A Division of North American Aviation, Inc. 43, 48
Autoclave Engineers.....117
* Avery & Saul Company..... 52
* Babcock & Wilcox Company.... 1
* Baird-Atomic, Inc.....91, 133
* Baldwin Lima Hamilton Industrial Equipment Division..... 51
* Barnstead Still & Sterilizer Co... 6
Bendix Corporation, Scintilla Division 55
Borden Chemical Company, The..130
* Branson Instruments, Inc..... 95
* Brooks & Perkins, Inc.....111
CPC Engineering.....119
* Cambridge Smelting Co..... 54
* Carlson, Inc., G. O..... 63
* Central Research Laboratories, Inc. 107
Chandler Evans Corp..... 98
* Crawford Fitting Company..... 59
Davison Chemical Co., Div. of W. R. Grace & Co..... 87
Duralab Equipment Corp.....126
* Ex-Cell-O Corporation..... 49
* Fisher Governor Company....10, 11
Flowline Corporation..... 46
* Foster Wheeler Corporation..... 47
* General Electric Company..... 57
General Electric Co., Metallurgical Products Dept..... 17
* General Mills Nuclear Equipment Dept. 93
General Precision, Inc., G.P.L. Division 96
Gray Tool Company.....127
* Great Lakes Carbon Corp.....119
* Griscom-Russell Company, The... 62
* Hagan Chemicals & Controls, Inc. 56
* Harshaw Chemical Company.....12
* Haws Drinking Faucet Co.....120
* High Voltage Engineering Corporation 105
Industrial Instruments, Inc....94, 124
International Business Machines.. 97
International Instruments Inc.....126
Jerpbak-Bayless Co.....131
Joy Manufacturing Company.... 15
* Kearfott Division, General Precision Inc.....118
* Keithley Instruments, Inc..... 60
* Kollmorgen Corporation..... 13
Koontz-Wagner Electric Co., Inc..120
* Lead Products, Inc..... 54
* Lenox Instrument Co..... 54
Leslie Regulators and Controllers.121
* Lionel Electronic Laboratories, Formerly Anton Electronic Laboratories, Inc.....108
* Lockheed Nuclear Products, Georgia Division.....3rd Cover
* Los Alamos Scientific Laboratory.114
* Martin Company..... 5
* Massachusetts Atomic Energy Commission 92
* Metals & Controls Inc., A Corporate Division of Texas Instruments Incorporated 2
* Midwest Piping, A Division of Crane Co..... 37
Mineral Concentrates & Chemical Co., Inc.....110
* Minneapolis-Honeywell..44, 45, 116
National Forge Company..... 95
* National Lead Co.....100, 101
Newbrook Machine Corporation..113
Newport News Shipbuilding & Dry Dock Company..... 42
* Nuclead, Inc..... 54
* Nuclear-Chicago Corp..... 66
* Nuclear Corporation of America. 50
* Nuclear Data, Inc.....115
* Nuclear Enterprises Ltd.....131
* Nuclear Materials and Equipment Corp.....129, 131
* Nuclear Measurements Corporation 53
NUCLEONICS WEEK.....110, 127
* Pechiney Division "Application Atomiques et metaux speciaux" 9
Penberthy Instrument Co.....130
Phelps Dodge Copper Products Corp. 61
Quartz & Silica..... 64
* RCA Service Company..... 7
RCA Victor Company Ltd..... 58
* Radiation Counter Laboratories, Inc. 33
Radiation Dynamics, Inc..... 39
Radiation Research Corporation.130
* Radiochemical Centre, The.....133
Research Laboratories United Aircraft Corporation..... 8
Rucker Company.....109
S.A.I.P. (Societe D'Applications Industrielles De La Physique)..128
Sames 130
Schuss & Co., John.....110
Stalker Corporation, The.....124
* Stokes Corporation, F. J.....122
* Superior Tube Company..... 16
* Technical Associates.....122
* Technical Measurement Corporation 36
* Texas Instruments Incorporated Metals & Controls, Inc..... 2
* Thermal American Fused Quartz Co., Inc.....102
Thermo Electric Co., Inc.....134
* Tracerlab Government Products Div. 89
* U. S. Pipe & Foundry Co., Steel and Tubes Division.....18, 19
* U. S. Stoneware.....125
Ultek Corp.....103
* United Nuclear Corporation..... 20
Vard, A Division of Royal Industries, Inc.....123
* Victoreen Instrument Company 4th Cover
* Vitro Chemical Company, A Subsidiary of Vitro Corporation of American 112
Westinghouse Atomic Power Div. 14
* Westinghouse Electric Corp., Electronic Tube Div..... 38
* Westinghouse Electric Corp..... 65
Wiggins Oil Tool Co., Inc., E. B.. 50
* Wiley & Sons, Inc., John..... 54
* Worthington Corporation..2nd Cover

*** See the advertisement in the November, 1960 issue of Nucleonics Buyers' Guide for complete line of products and services.**

PROFESSIONAL SERVICES.....136

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 135–137
Allis-Chalmers 135
AMF Atomics, Div. of American Machine & Foundry Co.....136
Atomic Personnel Inc.....136
Central Scientific Co.....136
General Electric.....137
Israel Atomic Energy Commission...137
Lawrence Radiation Laboratory.....137
Tullamore Electronics Corp.....136
Union Carbide Nuclear Co.....136

This index is published as a service. Every care is taken to make it accurate, but NUCLEONICS assumes no responsibility for errors or omissions.

NUCLEONICS ADVERTISING SALES REPRESENTATIVES

NEW YORK:
Donald J. Cassidy
500 Fifth Ave.
New York 36, N. Y.
OXford 5-5959

BOSTON:
Merrill J. Hosmer
McGraw-Hill Building
Copley Square
Boston 16, Mass.
COngress 2-1160

PHILADELPHIA:
Donald C. Knapp
Six Penn Center Plaza
Philadelphia 3, Pa.
LOcust 8-4330

CHICAGO:
Willis T. Smith
645 N. Michigan Ave.
Chicago 11, Ill.
MOhawk 4-5800

CLEVELAND:
Thomas K. Cogswell
55 Public Square
Cleveland 13, Ohio
SUperior 1-7000

LOS ANGELES:
Frederick R. Whitmore
1125 West Sixth St.
Los Angeles 17, Calif.
HUntley 2-5450

PORTLAND:
Scott Hubbard
Room 445, Pacific Bldg.
Yamhill Street
Portland 4, Oregon
CApital 3-5118

ATLANTA:
M. H. Miller
McGraw-Hill Pub. Co., Inc.
1375 Peachtree St., N.E.
Atlanta 9, Georgia
ATlanta 875-0523

DALLAS:
John G. Grant
McGraw-Hill Pub. Co., Inc.
901 Vaughn Bldg.
1712 Commerce St.
Dallas 1, Texas
RIverside 7-9721

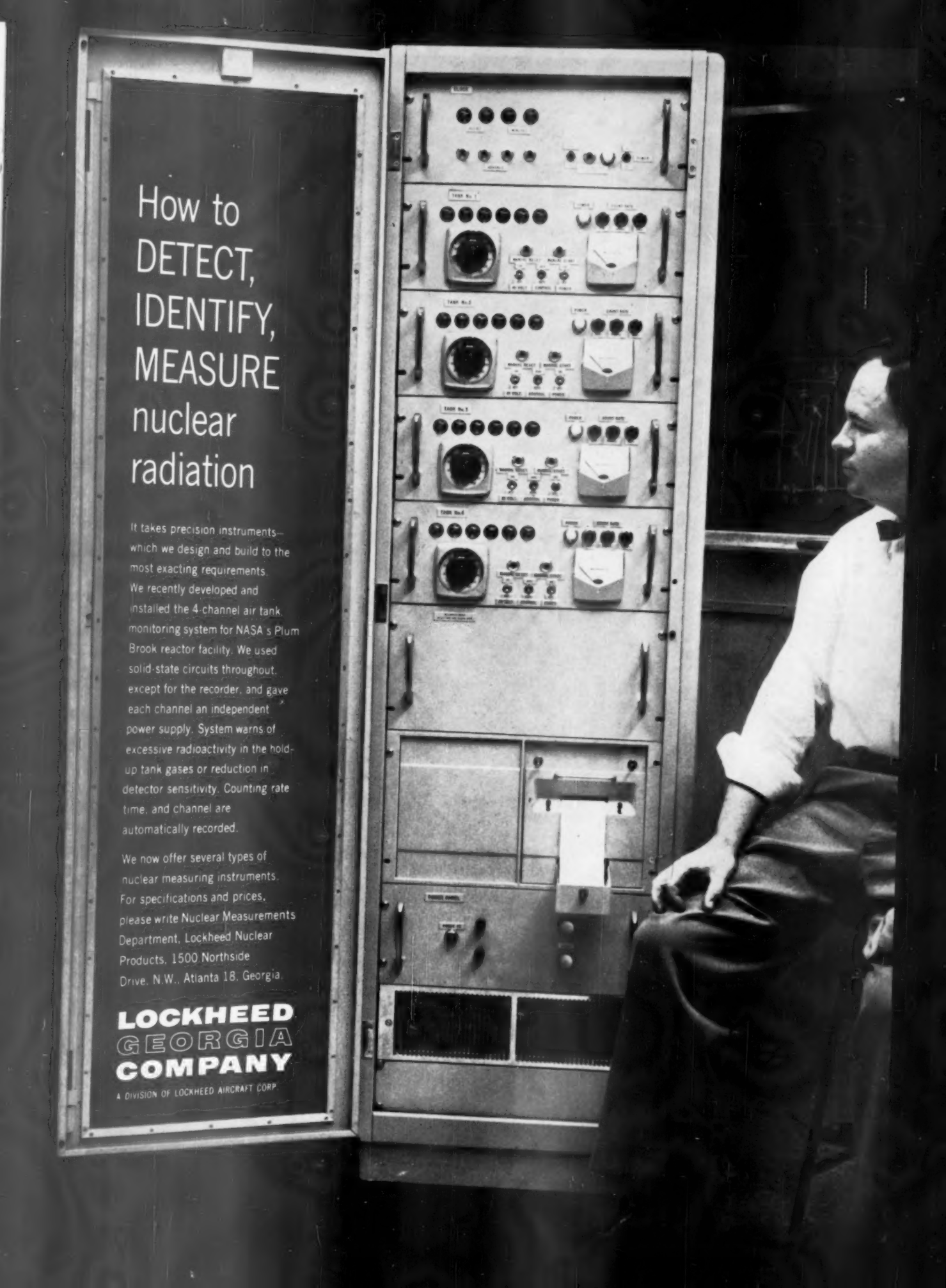
HOUSTON:
Joseph C. Page
McGraw-Hill Pub. Co., Inc.
Prudential Bldg., W-724
Holcombe Blvd.
Houston 25, Texas
JAckson 6-1281

DENVER:
John W. Patten
McGraw-Hill Pub. Co., Inc.
Tower Bldg.
1700 Broadway
Denver 2, Colo.
ALpine 5-2981

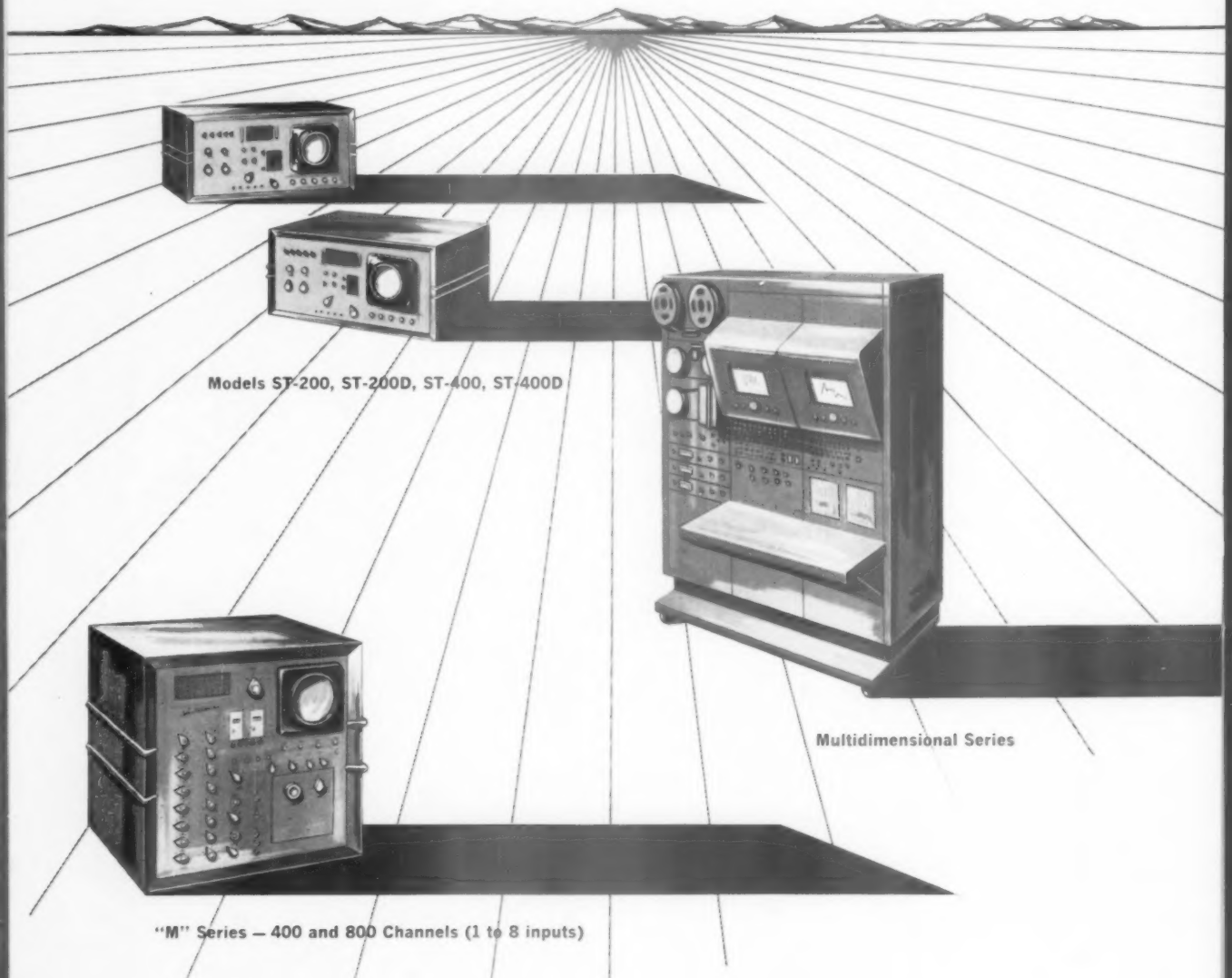
LONDON:
Edward E. Schirmer
Dennis McDonald
McGraw-Hill Pub.Co.,Ltd.
34 Dover St.
London W1, England

FRANKFURT:
Stanley R. Kimes
McGraw-Hill Pub. Co., Inc.
85, Westendstrasse
Frankfurt/Main, Germany

GENEVA:
Michael R. Zeynel
McGraw-Hill Pub. Co., Inc.
2, Place du Port
Geneva, Switzerland


How to
DETECT,
IDENTIFY,
MEASURE
nuclear
radiation
It takes precision instruments—which we design and build to the most exacting requirements. We recently developed and installed the 4-channel air tank monitoring system for NASA's Plum Brook reactor facility. We used solid-state circuits throughout, except for the recorder, and gave each channel an independent power supply. System warns of excessive radioactivity in the hold-up tank gases or reduction in detector sensitivity. Counting rate time, and channel are automatically recorded.
We now offer several types of nuclear measuring instruments. For specifications and prices, please write Nuclear Measurements Department, Lockheed Nuclear Products, 1500 Northside Drive, N.W., Atlanta 18, Georgia.
LOCKHEED
GEORGIA
COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORP.

VICTOREEN *First with the Finest in Analyzers*



Models ST-200, ST-200D, ST-400, ST-400D

Multidimensional Series

"M" Series — 400 and 800 Channels (1 to 8 inputs)

Victoreen's fine family of analyzers is widely recognized as being unparalleled in . . . versatility . . . long term usefulness . . . performance . . . value.

Their superior design concepts provide the highest degree of linearity and freedom from data shift, independent of counting rates. Linear selection memory circuitry assures rapid and reliable data handling. Multiple input configurations meet any user requirement.

These Victoreen analyzers provide all of the features most desired — and are the *only* analyzers which bear the name Tullamore — the Hallmark of Quality.

A-5102A

Service by
RCA SERVICE COMPANY
A Division of Radio Corporation of America

Victoreen

5806 HOUGH AVENUE • CLEVELAND 3, OHIO
EXPORT: 240 WEST 17th ST. • NEW YORK 11, NEW YORK

VICTOREEN—WORLD'S FIRST NUCLEAR COMPANY